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STUDIES IN MICROSCOPICAL SCIENCE,

EDITED BY

ARTHUR C. COLE, F.R.M.S.

VOL. I.

WITH FIFTY-THREE LITHOGRAPHED PLATES.



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1883.

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PREFACE.

The illustrations in this volume have been drawn on stone by Mr. JAMES W. WATSON, of Birmingham, from original drawings by Mr. J. E. ADY. A few of the figures have been copied from other works; in each such instance, however, the source is acknowledged.

All the articles, with the exception of three, have been written by Mr. ADY.

The excellence of the microscopical preparations which have been issued with this work, is due to the skill of Mr. MARTIN J. COLE.

The Editor is indebted to PROFESSOR HEDDLE for the articles on the red and white Syenites, of Lairg, and the serpentine of Portsoy. He desires to thank the following gentlemen for valuable assistance, advice and suggestions:—PROFESSORS NICHOLSON, HEDDLE, BALFOUR, DALLINGER, and MESSRS. WRIGHT WILSON, BLACKETT, CRISP, STEWART, HOGG, HAMPTON, THORP, and MUNRO.

LONDON,
May, 1883.

CONTENTS.

	PAGE.
No. 1.—Yellow Fibro-Cartilage, ...	1— 8
No. 2.—Dicotyledonous Stem, ...	9— 18
No. 3.—Bone, ...	21— 27
No. 4.—Monocotyledonous Stem,...	29— 32
No. 5.—Human Skin,...	33— 44
No. 6.—Pikrite, Inchcolm, Firth of Forth, ...	45— 64
No. 7.—Spinal Cord, ...	65— 73
No. 8.—Bracken Fern, ...	75— 78
No. 9.—The Liver, ...	79— 86
No. 10.—Fucus Vesiculosus, ...	87— 92
No. 11.—The Liver, ...	93—102
No. 12.—The Leaf, ...	103—108
No. 13.—The Kidney, ...	109—112
No. 14.—The Cluster Cup, ...	113—118
No. 15.—The Kidney, ...	119—126
No. 16.—Equisetum, ...	127—132
No. 17.—The Kidney, ...	133— 140
No. 18.—The Root, ...	141—146
No. 19.—The Lung, ...	147—150
No. 20.—Lycopodium, ...	151—156
No. 21.—The Lung, ...	157—160
No. 22.—Pilularia Globulifera, ...	161—164
No. 23.—The Lung, ...	165—172
No. 24.—Pilularia Globulifera, ...	173—176
No. 25.—The Thyroid Body, ...	177—184
No. 26.—Pilularia and Diabase, ...	185—196
No. 27.—The Thymus Gland, ...	197—200
No. 28.—The Lichen, ...	201—204
No. 29.—The Pancreas, ...	205—208
No. 30.—The Lichen, ...	209—216
No. 31.—The Pancreas, ...	217—220
No. 32.—Diabase, Coistorphine Hill, ...	221—226
No. 33.—The Spleen, ...	227—230
No. 34.—Juncus Communis, ...	231—234
No. 35.—The Spleen, ...	235—240
No. 36.—Euphorbia Splendens, ...	241—242
No. 37.—The Salivary Glands, ...	243—250
No. 38.—Red Syenite, Lairg, ...	251—256
No. 39.—The Alimentary Canal, ...	257—258
No. 40.—Ficus Elastica, ...	259—260
No. 41.—The Alimentary Canal, ...	261—264
No. 42.—White Syenite, Lairg, ...	265—270
No. 43.—The Alimentary Canal, ...	271—274
No. 44.—Ribes Nigrum, ...	275—280
No. 45.—The Alimentary Canal, ...	281—284
No. 46.—Pinus Sylvestris, ...	285—286
No. 47.—The Alimentary Canal, ...	287—292
No. 48.—Porphyritic Basalt, ...	293—298
No. 49.—The Alimentary Canal, ...	299—302
No. 50.—Serpentine, The Lizard, ...	303—304
No. 51.—The Alimentary Canal, ...	305—312
No. 52.—Serpentine, Portsoy, ...	313—318
Appendix of Errata, ...	319—320
Index, ...	321—333



YELLOW FIBRO-CARTILAGE.

L.V.S. Pinna of Ear of Cow \times 333.
Double Stained in Logwood and Eosin.

Etymology.—FIBRO-CARTILAGE, from FIBRE and CARTILAGE. FIBRE or FIBER, n. [Fr. *fibre*, from Lat. *fibra*; Pr., Pg., and It. *fibra*, Sp. *fibra*, *hebra*]. A delicate thread-like or string-like substance, of which the tissues of living things are in part composed.

CARTILAGE, n. [Fr. *Cartilage*, Lat. *Cartilago*]. *Anatomy*,—One of the connective tissues (REICHERT) found in the animal body. It consists of cells imbedded in a whitish, translucent, elastic, fibrillated, or apparently homogeneous matrix. The cells secrete the matrix, or intercellular substance, and the texture thus constituted forms one of the most important tissues in the bodily economy. It may be seen forming a kind of skeleton in the *Medusae*, where the cells are large, of regular shape, and the structure exhibits but a scanty amount of intercellular substance. The shape and position of the cells, the varying proportion of the intercellular substance, and the minute changes which both of these elements undergo, form the basis upon which the most rational classification of cartilage has been founded. Before we leave the *Invertebrata*, we find this tissue very curiously developed in the *Cephalopoda*, where the cells throw out radiating processes which unite with those of subjacent cells, and form a structure similar to, but even more highly developed than, the cartilage of some of the Elasmobranch fishes (*Selachii*).

Cartilage forms the entire permanent skeleton of many of the higher animals (*Elasmobranchii*), whilst in others it constitutes a varying proportion of that structure, which ultimately in the highest vertebrates persists only in such situations as the articular ends of the bones between the ribs and sternum, the walls of the trachea and bronchi, the larynx, the intervertebral discs, sacro-iliac synchondrosis, symphysis pubis, interarticular situations, glenoid and cotyloid ligaments, the grooves for tendons, the ear, and in all parts where a decidedly firm yet less yielding structure than bone is required. In all other parts it becomes eventually replaced by bone, and in certain pathological conditions (*Enchondromata*) invades other parts of the body.

DESCRIPTION.

The differentiation of the matrix of cartilage forms the chief item in its most modern classification, which, in the higher *vertebrata*, recognises it as *hyaline*, *white fibro*, and *yellow fibro-cartilage*. It is with the last of these that we are at present concerned.

The specimen we have selected for our illustration is a longitudinal vertical section of the pinna of the ear of the cow, which has been stained with logwood and eosin. It will be observed that the re-agents have acted upon the tissues in a most remarkably selective manner; the cartilage has been stained a beautiful purple hue by the logwood, the eosin has acted upon the surrounding structures, staining the protoplasm and nuclei of the cartilage cells, the perichondrium, connective tissue, muscular fibres, and skin, of a reddish colour, whilst the hairs and sebaceous glands have resisted the action of both of the dyes. The cartilage affords a most typical example of the yellow fibrous variety.

Yellow fibro-cartilage has many synonyms, amongst which the more appropriate are *reticular*, *spongy*, and *elastic* cartilage. It consists of cells imbedded in a matrix of yellowish colour, and strongly defined fibrous texture. It is more flexible and elastic than either hyaline or white fibro-cartilage, and the fibres in the matrix have all the characters of the fibres of elastic tissue. It occurs most typically in the pinna of the ear and eustachian tube, in the epiglottis, and corniculæ laryngis. If a section of the arytenoid cartilage be made in the direction of, and through the cornicula laryngis, the hyaline cartilage of the former is seen to merge gradually into the elastic cartilage of the latter. A section such as this, examined with a magnifying power of 300 diameters, shows very clearly that a structural change has taken place in the hyaline matrix, and given rise to a network of elastic fibres, amongst which the cartilage cells appear.

THE CELLS in the pinna of the cow's ear are of an ellipsoidal shape, and of an average size of 1-1800th in. through the major, and 1-2250th in. through the minor axis. A measurement of the sizes of the cells in the pinna of the ear and in the epiglottis of the cow, sheep, dog, cat, rabbit, pig, and human subject has shown us that they vary very considerably in their dimensions, even in the same piece of tissue, so that we are warranted in assigning very little value to this item.

An examination with a power of about 300 diameters, enables us to make out the following features:—The cells are seen to be ovoid in form, and surrounded by a meshwork of fibres. Towards the periphery of the cartilage they are more numerous, somewhat flattened in contour, and a relatively larger number of the cells seem to be undergoing division.

In most of the cells the nuclei are plainly visible.

By substituting a power of 800 diameters, the following additional characters may be recognised:—The central cells are seen to be surrounded by a thin lamella of hyaline matrix; in a few cases a distinct capsule may be seen around some of the cells, especially those undergoing division, and two kinds of nuclei may be detected; one, a smooth nucleus containing a nucleolus, the other (sometimes occurring in pairs) of a granular aspect without nucleoli. In the stained specimen the protoplasm of the cells may occasionally be seen shrunk from the cell-wall without sign of laceration around the nucleus, in which instance the capsular nature of the cell-wall is rendered apparent, and its origin as a *secretion* of the protoplasm demonstrated.

THE MATRIX multiplied 300 diameters exhibits a close meshwork of fibres with interstitial hyaline substance; this latter is more clearly seen in the vicinity of the peripheric cells. The fibres are branched, refract light strongly, and in all respects closely resemble those of elastic connective tissue.

A power of 800 diameters reveals a hyaline matrix immediately around all the cells, and, to some extent, between the fibres of the matrix. Many of the fibres are seen to be cut transversely, and thereby give the tissue a granular spongy aspect. A careful examination of the fibres shows them to be in direct continuity with the fibres of the perichondrium, where they appear as fine elastic fibres.

No systems of blood-vessels or nerves have been discovered in cartilage of any sort. Its nutrition must therefore depend upon its porosity, which is sufficient to permit of the irrigation of its elements by the penetration of lymph from the neighbouring vessels. Occasionally blood-vessels are found in cartilage, chiefly of the hyaline variety, when they appear in peculiar dendritic forms, and as RANVIER* has shown, only as a preliminary to ossification.

Yellow fibro-cartilage is preceded in the embryo by hyaline cartilage. A study of its development shows that the elastic fibres appear in the matrix often at a distance from the cells, and they are doubtless produced by the coalescence of minute particles of elastic substance which result from the metabolism of chondrogen.**

THE ACTION OF REAGENTS.—If a thin section of the elastic fibro-cartilage of the external ear of the cow be examined under a magnifying power of about 800 diameters, and acted upon by various reagents, the following details may be learned concerning it, which the mere inspection of a mounted preparation cannot reveal.

WATER, and many staining reagents cause a shrinkage of the protoplasm without laceration around the nuclei of the cells. From this we learn that the capsular cell-wall, which may become apparent, is a secretion of the protoplasm, and not a mere modification of its periphery. Most of the staining reagents act upon the protoplasm of the cells more markedly than upon the matrix, and bring the nuclei and nucleoli into view more distinctly.

ACETIC ACID and CAUSTIC ALKALI render the nuclei and nucleoli distinct by causing the protoplasm of the cells to become hyaline. Their reaction on the matrix will be noted below.

GOLD-CHLORIDE is a valuable reagent in the study of cartilage. It dyes the cells violet without causing the protoplasm to shrink.

OSMIC ACID reveals the presence of fatty particles in the cells, by rendering them black, it also darkens the whole tissue slightly.

IODINE stains the protoplasm of the cells a pale yellow colour, the nucleus somewhat more deeply, and indicates the presence of small

* L. RANVIER, *Traité Technique d'Histologie* Paris, 1875, p. 290.

** H. MULLER, *Verhandlungen der physikal-medizin, Gesellschaft zu Würzburg*, x. p. 132.

particles of glycogen in the protoplasm by turning them a rich brown colour.

Prolonged boiling of the matrix of hyaline cartilage in water gives rise to an albuminoid substance allied to gelatine and termed *chondrin* (C 49·9, H 6·6, N 14·5, SO₄, O 28·6 per cent.), but as chondrin is readily soluble in hot water, and the matrix of the cartilage is not, it is supposed to be derived from a hypothetical substance which has been termed *chondrogen*. Yellow fibro-cartilage, when boiled, yields a very small quantity of chondrin and a large amount of another albuminoid, *elastin* (C 55·5, H 7·4, N 16·7, O 20·5, per cent.) Elastin may be easily distinguished from chondrin and gelatine in its property of being quite insoluble in hot water; it still further differs from gelatine by being unaffected by acetic acid, but it may be broken down by the prolonged action of a strong solution of potassium hydrate into granules which dissolve in water.

METHODS OF PREPARATION.

The consistency of yellow fibro-cartilage obviates the necessity of any special hardening process to render it suitable for cutting into sections. Where it is desirable to retain the cartilage *in situ*, the tissue may be placed in rectified spirit for twenty-four hours, or, better still, in a saturated solution of picric acid for forty-eight hours. Thus treated, the tissue may be imbedded in a piece of carrot or in paraffin, and either sliced by hand with a sharp razor, or in the well-known microtome of Mr. A. B. STIRLING, late sub-curator of the Anatomical Museum of the University of Edinburgh. But by far the best results are obtained by slicing the fresh tissue with the aid of a freezing microtome.*

For purposes of study, the sections of fresh cartilage made with the freezing microtome or cut by hand, should be examined in a 0·75 per cent. sodic chloride solution, or in dilute glycerine with powers of from 300 to 800 diameters. The actions of osmic acid, iodine solution, acetic acid, potassium hydrate, and water, should also be studied on sections of the fresh tissue.

For permanent preparations various staining processes are employed, of which the following are the best:—

OSMIC ACID.—Place the sections of *fresh* cartilage in a one per cent. solution of osmic acid for about twenty-four hours, wash in distilled water, and transfer to dilute glycerine for an hour, after which they may be mounted in glycerine or glycerine jelly.†

*The freezing microtome devised by PROFESSOR RUTHERFORD, of the University of Edinburgh, first described by him in the *Journal of Anatomy and Physiology*, May, 1871, and subsequently improved and fully described in his *Outlines of Practical Histology*, 2nd edition, 1876, pp. 164-169, is an instrument of great practical utility, inasmuch as it can be used for cutting unfrozen tissues imbedded in carrot or paraffin, or for cutting them hardened by freezing. But by far the best freezing microtome, as such, is the one invented by Mr. WILLIAMS for the Quekett Microscopical Club, and described in the *Journal of the Royal Microscopical Society*, August, 1881, pp. 697-699. Williams's microtome has been adapted for use with ether as the freezing agent by Mr. J. W. GROVES, and we can confidently state that this is the best ether freezing microtome now in use. Both forms are made by Mr. SWIFT, of Tottenham Court Road, London, W.C.

† In all cases where glycerine jelly is used as the preservative medium, it is advisable to steep the specimen in dilute or pure glycerine before hand.



J. del. ad. nat.

J.W. Watson. del. et lith.

YELLOW FIBRO-CARTILAGE

Ear of Cow.

X333

SILVER NITRATE.—The sections of the *fresh* tissue must be well washed in distilled water, for the purpose of removing any chlorides which may be present, and placed in a one-half per cent. solution of silver nitrate for about five minutes, or until they assume a whitish appearance. They should then be washed in ordinary water, and exposed in it or in a weak mixture of alcohol and water to diffuse daylight, until they become brown in colour (due to the precipitation of the silver in form of the black oxide). They may then be mounted in glycerine, glycerine jelly, or Farrants's solution.

GOLD CHLORIDE.—*Perfectly fresh* sections are absolutely necessary in order to ensure success in this beautiful method. The slices are to be placed in a one per cent. solution of chloride of gold for about half-an-hour, thoroughly washed in distilled water and transferred to acidulated water (2 or 3 drops of acetic acid to one ounce of water). Exposure to diffuse daylight for about twenty-four hours reduces the gold, and thereby stains the cartilage violet. The special value of this re-agent depends upon the fact that it dyes the cells of the cartilage without causing any shrinkage of the protoplasm. The sections should be mounted in glycerine, glycerine jelly, or Farrants's solution.

CARMINE, LOGWOOD, EOSIN, and the ANILINE DYES† may be used for staining sections which have been hardened in alcohol. They may be mounted in canada balsam or dammar solution.

DR. FRANCES ELIZABETH HOGAN'S METHOD.

(i.) Steep the sections (fresh or hardened) in alcohol for about five minutes.

(ii.) Transfer to a watch glass full of tincture of steel for two minutes.

(iii.) Remove into a two per cent. solution of pyrogallie acid in alcohol.

When the desired depth of colour has been attained (in one or two minutes), wash the sections in distilled water, and mount them in glycerine, or glycerine jelly. This process imparts a beautifully soft neutral tint to the specimens.

PICROCARMINE* is a reagent which is specially useful for staining sections which have been hardened in picric acid. The cartilage is rendered bright yellow, whilst the perichondrium and subjacent tissues are stained in varying shades of red. The red colour also affects the neuclei of the

† In the *Morph : Jahrbuch*, vi, 1880, pp. 43-44. DR. M. FLESCH notes that HERMANN has shown that the aniline dyes may be employed to stain the nuclei of tissues exclusively. To do this the sections must be freed from all trace of acids or substances likely to form chemical compounds with other substances, by soaking in distilled water. The sections are to be transferred to an alcoholic solution of the staining reagent for a few seconds, washed in distilled water, and placed in absolute alcohol. As soon as the nuclei are sufficiently stained, they may be mounted in canada balsam or dammar solution.

* See RUTHERFORD, *Outlines of Practical Histology*. Second Edition. London, 1876, p. 173.

Most of the staining reagents used in microscopical work are excellently prepared and sold by W. MARTINDALE, Pharmaceutical Chemist, 10, New Cavendish Street, Portland Place, London, W.

cartilage cells, which thus appear as so many red spots in the yellow matrix. The sections should be mounted in canada balsam or dammar solution.

LOGWOOD and PICROCARMINE.

(i.) Make a strong infusion of logwood chips in tepid water. Add three or four drops of this to a watch glass full of distilled water, and place the sections in it for about fifteen minutes.

(ii.) Wash the sections thoroughly in ordinary water, transfer to acidulated water for a few seconds (30 minims of acetic acid to one pint of distilled water) to get rid of superfluous staining; re-wash thoroughly in ordinary water.

(iii.) Place in rectified spirit* for an hour.

(iv.) Transfer to picrocarmine solution for about three minutes.

(v.) Wash thoroughly in ordinary water and transfer to rectified spirit. Mount in canada balsam or dammar solution.

LOGWOOD and EOSIN.—Follow the first three processes indicated in the preceding method.

(iv.) Transfer to an alcoholic solution of eosin (three grains of eosin to one ounce of alcohol) for an hour, or the sections may remain in this solution for any length of time, as the eosin only acts upon the tissue elements to a certain extent, and no further.

(v.) Wash quickly in rectified spirit. If the sections are allowed to remain in the spirit the eosin staining will be removed, hence it is necessary merely to *rinse* them in spirit and transfer them quickly to oil of cloves previous to mounting them in canada balsam or dammar solution.

The successful mounting of stained sections in canada balsam or dammar solution very largely depends upon the course of previous treatment. To ensure good results, the following details should be attended to:—

(a.) The sections must be deprived of any water they may contain by soaking them in rectified spirit or alcohol.

(b.) They must be *cleared*. For this purpose turpentine and the essential oils are used, especially cajeput oil, and the oil of cloves. The sections, on removal from the spirit or alcohol, are to be *float*ed on to the *surface* of a watch glass full of oil of cloves; the oil in a few minutes will permeate the tissue, which may be removed and mounted in canada balsam or dammar solution as soon as it sinks to the bottom of the oil.

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* Rectified spirit of sp. gr. 0·838 should be used here; where, however, it cannot be easily procured ordinary methylated spirit may be substituted.

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T. S. DICOTYLEDONOUS STEM.

COPPER BEECH.

(*FAGUS CUPREA*).

Stained Carmine and Iodine Green.

× 25 diameters.

Etymology.—BEECH, n. [A.S. *bece*, *boc*, D. *benk*, Icel. *beyki*, Dan. *bøj*, Sw. *bok*, O. H. Ger. *poucha*, M. H. Ger. *bouche*, N. H. Ger. *buche*, Russ. *buk*, Lat. *fagus*, Gr. *φηγός* from *φαγω*, because the seeds are edible, Arm. *fuw*, *fuw*, W. *ffwydd*]. (*Botany*), A tree of the genus *Fagus**.

DESCRIPTION.

The subject of our illustration for this number, is a transverse section through the internode of the stem (a first year's twig) of the Copper Beech. It has been selected because it shows in a typical manner the arrangement of the tissues in a dicotyledonous stem, and also because it affords an example peculiarly well adapted for the exhibition of the double staining process applied to vegetable sections.

It will be observed on reference to the illustrated plate, that the structure of the stem is very clearly brought out by the differentiation of the staining reagents. The *epidermis* is not affected by the dye, and appears as a boundary layer of brownish cells. Beneath this comes a broad layer of thin walled angular cells which have been coloured red; immediately contiguous with the epidermal tissue, and with the green-coloured bundles (*bast fibres*) the cells of this *cortical layer* are seen to be very much smaller than those towards the centre of the layer; this has been caused by a stretching of these cells from within by the tissues formed beneath them, which in their subsequent growth causes the cortex to split. The cortical cells are seen to be interruptedly connected with the cells of the *pith* or *medullary cells* by means of radiating rows of parenchymatous cells termed the *medullary rays*. Both the pith and the medullary rays have been dyed green, although in some cases they are rendered a reddish purple.

Lying between the medullary rays and forming a well defined series of wedge-shaped arrangements, are the *fibro-vascular bundles*. The *wood* or *xylem* portion of each of these bundles is coloured purple (in some cases green), whilst the *bast* or *phloëm* has its two layers—the *bast-parenchyma*

*For a description of the genus *Fagus* see SIR J. D. HOOKER, *The Students Flora of the British Islands*, 2nd ed., London, 1878, p. 364.

and *sieve tubes* red, and the thicker-walled *liber* or *bast fibres* a bright green. Separating these two factors (the xylem and the phloëm), the *cambium zone*, consisting of thin walled angular cells coloured red, is clearly defined.

All these details can be distinctly made out with a magnifying power of 25 diameters. In order to determine the special characteristics of the various cells which constitute this aggregate, we must have recourse to longitudinal, tangential, and oblique sections made from the fresh stem, and with the assistance of several reagents, examine them under varying powers of the microscope. As our intention in selecting this specimen is to give a description of the minute structure of the dicotyledonous stem, we shall lay before the reader a brief statement of what is understood by that structure, and direct his attention to methods which he may employ with advantage in a further study of this subject.

To fully understand the value of the various groups of cells which we observe in our section, we must trace them from their embryonic origin to their mature condition. The *ovary* of the flower of the copper beech is trigonous and three-celled; each complete cell contains two *ovules*, which are pendulous from the top. The minute examination of an ovule reveals a central conical *nucleus* invested by two coats. It is with the partial life history and further development of the nucleus that we have to deal. Within the nucleus there is a sac termed the *embryo sac* in which certain cells are developed; one of these cells differs from the rest both morphologically and physiologically, and is termed the *mother-cell of the embryo*; the remaining cells are called *endosperm cells*. The processes of impregnation and fertilization result in the breaking up of the mother-cell into an equivalent number of *daughter-cells*, each one of these in its turn subdivides again, altogether forming a cellular structure known as the *embryo*. As the embryo grows its cells become arranged in a definite order characteristic of the group of plants to which it belongs; the order of succession in the formation of the independent primary tissues in this case is as follows:—The outer layer of cells becomes arranged into a continuous investing system termed the *epidermal tissue* or *dermatogen*. Immediately after the formation of this, the cells which make up the layers below it develop into a *primary cortical tissue*, or *periblem*. It will now be understood that the apex of the embryo at this stage is composed of the cellular elements of the dermatogen and periblem. The cells beneath the periblem thus do not enter into the structure of the extreme end of the apex, but lie immediately underneath in a somewhat lateral situation. These cells constitute the *intermediate tissue* or *plerome*, which undergoes remarkable changes culminating in its separation into two distinct primary tissues, one formed from either the whole or a part of its outermost cells, which become prosenchymatous and are collectively termed the *procambium*, the other remaining in its original parenchymatous condition, and known as the *fundamental tissue*.

Whilst these changes are going on the embryo increases considerably in size by the growth and multiplication of its cells, and commences to assume a definite external shape. The primary tissues go on growing actively, and ultimately are converted into permanent independent groups which perform definite functions in the plant economy. Some of these groups become the seat of complex chemical changes, and in the course of

time give rise to a structure, upon the passive mechanical properties of which the healthful condition of the other parts depend ; others are destined to continue growing actively, and adding to the individual plant in a manner characteristic of the group to which it belongs ; whilst to others are allotted peculiar powers of transformation and metabolism which give rise to varied phases of development in the formation of special organs, such as those of alimentation, respiration, secretion, and generation.

The young embryo, still enclosed within the coats of the ovule, undergoes all the changes which bring it to the threshold of those permanent conditions, the ultimate results of which we have just alluded to. At this stage its external form clearly shows it to be a dicotyledonous plant, in its possession of a *radicle* or *primary root*, a *plumule* or primary stem, and *two seed leaves* or *cotyledons*. The cotyledons in the beech plant, although somewhat fleshy and full of large cells containing nutritious matter, are plaited, and become leafy after germination. In the condition just stated the embryo remains, and is still covered by the nucleus and coats of the ovule which grow concomitantly with it, and envelop it as a *seed coat*. Under favourable conditions of temperature and moisture, the seed germinates ; its outer coat bursts and liberates the embryo, whose radical enters the earth and becomes the root, whilst the plumule ascends from the earth and becomes the stem of the future plant. The apex of the stem remains cellular throughout the life of the plant, and is known as its *growing point*, because the growth of the length of the stem by the addition to it of new cells takes place in this part.

The dermatogen of the embryo gives rise to the *epidermis* of the young plant, which consists of one layer or more of similar closely contiguous cells. The outer side of the most external layer of these cells gradually becomes hardened, changes in character, and is then called the *cuticula*. The cell walls which thus unite, form a thin, tough, and apparently homogeneous membrane which effectually resists atmospheric influences, and is even insoluble in concentrated sulphuric acid or a saturated solution of potassium hydrate. The epidermal cells are of very various shapes in different plants ; in some they are wholly parenchymatous and thin-walled, in others they may be thick walled and prosenchymatous, and in many plants they become collenchymatous. In all perennial dicotyledons, suberous tissue formed from the primary epidermis, or from the subjacent cortical cells, eventually replaces the Epidermis. The cells of this layer usually contain clear or coloured fluids, and sometimes crystals and raphides ; they very rarely possess chlorophyll. As they grow, some of them separate from one another, and give rise to a space or *Stoma*, which usually becomes surrounded by two or four *guard-cells* ; these latter are thin walled crescentic cells full of granular protoplasm, and contain chlorophyll bodies. The Epidermal cells very often develop eccentrically, and form *hairs* or *trichomes*, *stinging-hairs*, *bristles*, *prickles*, *scales*, and *glands*, all of which arise as adaptations to previous, continued, or present external circumstances.

The *primary cortex* of the young plant which develops out of the periblem of the embryo is composed of thin walled parenchymatous cells, which are full of granular protoplasm, and contain starch grains, and

chlorophyll bodies ; it is this layer which imparts the green colour to young stems. It sometimes contains other kinds of cells, such as bast fibres, bast vessels, laticiferous, utricular, and glandular cells and vessels. But, ere long, it undergoes profound changes, the precise sequence of which are still enigmas to the morphological botanist. The rapid growth of the tissues beneath it causes so great a tension, that it is rent and split in all directions ; the spaces thus formed are filled up partly by cells from the bast portion of the under-lying fibro-vascular bundle, and from those of the intermediate tissue, and partly by new suberous tissue. This disintegrative process and its subsequent reparation becomes evident in the desquamation of the so-called *bark* in most plants, and the new cortical layer so formed from time to time, and called the *secondary cortex*, in contradistinction to the primary cortex of the young plant, is thus an entirely new and derivative structure.

Concurrently with the changes which go on in the dermatogen and periblem of the embryo, its *procambium*, which consists of a thin walled parenchyma without intercellular spaces, is gradually modified. These changes are heralded by a transformation of some of its rows into bast-cells, and continue until a series of *fibro-vascular bundles* have been fully developed. The fibro-vascular bundles typically lie in the fundamental tissue in the form of wedge-shaped arrangements, constituting a hollow cylinder interrupted by radial bands of intermediate tissue, which are known as the *medullary rays* ; they also obtain as isolated bundles in the fundamental tissue, and thus somewhat resemble those of monocotyledons.

The fibro-vascular bundles are formed near the growing point. The procambial layer, in its transformation into permanent tissue, gives rise either to a continuous layer of formative cells, termed the *Cambium layer*, or to an interrupted series of *Cambium bundles*. In both cases the Cambium zone is composed of thin walled actively growing cells, which are continuous with the growing apices of the stem and root. They produce, on their inner side, wood cells and vessels, which form the *xylem portion*, and on their outer side bast cells and vessels, which constitute the *phloëm portion* of the stem.

Anomalous arrangements of the fibro-vascular bundles in Dicotyledons are rare. We may here, however, direct attention to some of the more remarkable variations. In *Clematis* we have twelve wedge-shaped masses, alternately large and small ; an arrest of the development of six of the primary wood bundles has taken place. Amongst the *Bignoniaceæ* some of the bundles are also arrested in their growth ; in spite of this, most of these cases exhibit externally cylindrical stems ; this is occasioned by the greater development of the bast tissues which fill up the fissures in the wood. In the *Malpighiaceæ*, some parts are fully developed, whilst others are arrested, and the stem becomes lobed, the lobes being separated from the main mass by a layer of bark. In the *Sapindaceæ*, the ordinary typical dicotyledonous stem is surrounded by similar peripheral systems, which produce the appearance of a union of several stems, but, in reality, the peripheral structures are lobes which have been nipped off from the central stem, and in them we do not, therefore, find spiral vessels such as obtain in the central bundles, and form what used to be called the *medullary sheath*. In *Bauhinia* the wood mass is deeply fissured, the fissures being apparently filled with secondary cortex. In *Gnetum* the central pith is surrounded by concentric layers of fibro-vascular bundles ; in each circle there is an xylem and a phloëm portion, and these are increased from year to year by false cambium ; in addition to these, new fibro-vascular bundles are formed. In *Peronia* there is a central parenchyma,

in which are scattered numerous closed fibro-vascular bundles like those of monocotyledons, superadded to its ordinary fibro-vascular system. Lastly, in *Piper* we have a series of wedge-shaped masses of the ordinary kind, but in the central pith a number of closed bundles obtain; these last appear to anastomose at the nodes and enter the leaves. They differ from the ordinary bundles, in being destitute of hard bast.

The developmental history of the course of the vascular bundles through the plant into its branches, leaves, &c., has not yet been satisfactorily made out, although the elaborate researches of NAGELI and others appear to prove that their growth advances from the several apices towards the main stem, where they form a union with its system.

The vascular bundles as they descend in the stem are thicker and thicker, and often join together to form a continuous ring, only broken here and there by very narrow medullary rays. The xylem portion consists of:—1°. Prosenchymatous cells which are strongly lignified, of a fusiform shape, unbranched, and usually furnished with minute bordered pits; they very rarely become septated, and generally contain starch during the winter months, when the life of the plant becomes dormant. 2°. Parenchymatous cells: these cells are not so strongly lignified and thickened as those last mentioned; they never develop bordered pits, but are usually dotted, and store starch during the winter. Neither of these two forms of cells exhibit spiral markings. 3°. Vessels: these are mostly pitted, especially in the younger portions of the xylem. Towards the pith, however, they are found with annular, spiral, and reticulated markings. The spirally thickened vessels usually occur nearest the pith and collectively form the so-called *medullary sheath*. The partition walls of the vessels are usually disposed in an oblique or horizontal position and are perforated by scalariform or pitted openings in the pitted and reticulated vessels, and by pits alone in the annular and spiral vessels. The vessels are of largest size in the young wood or wood of the last year's growth; they become lignified at an early stage, when they lose their sap and become filled with air. They are sometimes found full of resin, latex, &c., but this is always the result of an extravasation from other special structures. The youngest wood, *i.e.*, that which lies nearest to the cambium zone and called the *alburnum* is generally full of sap and the walls of its elements are not so greatly thickened and lignified as those of the older wood or *duramen*, which have undergone complete lignification, and are devoid of sap. All these elements do not necessarily occur in every plant.

The phloëm portion of the fibro-vascular bundles is produced from the outer layer of the Cambium zone, and early separates into two distinct portions; an outer *hard bast*, and an inner *soft bast*. The hard bast consists of prosenchymatous cells, which are called *bast fibres*, *bast tubes*, or *bast cells*, they are unbranched and fusiform, they rarely become septated, and when young contain sap, but they soon lose this and function thereafter as air tubes. The soft bast is composed of parenchymatous cells with thinner walls, but otherwise similar to the parenchyma of the xylem, and of vessels which are either *sieve tubes*, or laticiferous vessels, or both.

The *fundamental tissue* of the Embryo, which is formed from the inner portion of the plerome, consists of thin walled parenchymatous cells, full

of protoplasm containing starch. It changes but slightly compared with the other tissues of the plant, and forms the *central pith* of the stem, and the intermediate tissue of the *medullary rays*. Throughout its whole life-history it remains in the form of parenchyma. The cells of the medullary rays may be readily distinguished from those of the pith by their shapes, they are elongated radially, and are seen to be narrow in a transverse section of the stem, while the pith cells are more or less of regular polygonal forms. The fibro-vascular bundles of the stem of all old and sometimes of young plants are very often seen to be penetrated by ingrowths resembling the medullary rays in all particulars, with the exception that they extend inwards from the Cambium zone, but do not reach the pith. These *secondary medullary rays* are produced by a proliferation of the cambial cells of the original medullary rays, and invade the substance of the xylem interruptedly, as can be easily made out from tangential sections of the wood. The primary fundamental tissue, which afterwards develops into the pith and medullary rays with their derivatives, is singularly conservative in always producing the same form of parenchymatous cells throughout its existence. The so-called "silver grain" of the wood is formed by the tissue of the medullary rays.

METHODS OF PREPARATION.

The histological structure of the tissues of the higher plants may be studied by means of sections, and by digestion, maceration, and teasing. We have here to deal with the methods of preparing sections as permanent objects for the microscope. Unlike the tissues of animals, those of the higher plants do not require any previous treatment to render them suitable for cutting into sections. The slices may be cut with a sharp razor in the hand or in a microtome. The methods employed for the staining and mounting of these sections are innumerable. In this paper we shall give a detailed account of the way in which our section of the stem of the copper beech was stained and prepared, and refer in the appended bibliography to other published accounts of some of the best processes.

STAINING IN CARMINE AND IODINE GREEN.

1ST PROCESS.—*The Sections must be bleached.* This may be accomplished either by the prolonged action of alcohol, or by the use of a solution of chlorinated soda. The value of alcohol as a bleaching reagent depends upon the fact that the cell contents remain but slightly altered, but it has the disadvantage of being an imperfect decolouriser. Chlorinated soda, on the other hand, is a perfect decolouriser, but unfortunately it destroys the cell contents; on the whole, however, it is to be preferred to alcohol, as in the cases where it is generally used, one seeks only to preserve the shape and position of the cell walls.

A solution of chlorinated soda may be made as follows :—To a pint of distilled water add two ounces of fresh chloride of lime, shake the mixture thoroughly, and, whilst the lime is in partial suspension, slowly add to it a saturated solution of common washing soda until it becomes thick and turbid; allow the solution to stand until it has thoroughly settled, when the clear supernatant liquid should be siphoned off, and kept in a well-stoppered bottle in a dark place.



A. del. ad. nat.

J.W. Watson, del. et lith.

T. S. STEM OF COPPER BEECH
X 25

Watson & Son, Chromolithogrs, Newhall St. Birm.

The sections are to be placed in a small bottle full of this solution, for from six to twelve hours, or until they are thoroughly bleached. If this reaction is permitted to go on too long, the sections will be destroyed by a separation of their tissue elements.

2ND PROCESS.—Wash thoroughly in five or six changes of water during the course of about twenty-four hours. It is advisable to use tepid water in some cases, but as a general rule ordinary cold water is amply sufficient. The sections may now be placed in dilute alcohol (fifty per cent.) until they are required.

3RD PROCESS.—The sections must be subjected for about twelve hours to the action of a *mordant*, which may be prepared as follows :—(A). Make a five per cent. solution of sulphate of alumina in distilled water. (B). Make a five per cent. solution of lead acetate in distilled water. To one part of A add gradually three parts of B, and lay aside to settle; siphon off the clear liquid from the top, filter, and keep it in a well-stoppered bottle. When required for use, one part of this solution should be mixed with four or five parts of distilled water and filtered; it may sometimes, however, be necessary to use a stronger solution, and this should, by preliminary experiment, be made to meet the requirements of the special case.

4TH PROCESS.—*Staining in Carmine*.—Transfer the sections from the mordant into an ammoniacal solution of carmine for an hour or two, or until they are thoroughly stained. They must then be well washed in acidulated water (thirty drops of nitric acid in a pint of distilled water), and finally in distilled water; from this they may be transferred to alcohol for one or two hours, or until they are required.

The carmine solution is to be prepared as follows :—

Carmine ...	...	...	...	15 grains.
Ammonia (strong)	...	...	...	15 grains.
Distilled water ...	...	...	...	2 ounces.

Dissolve the carmine in the ammonia in a test tube, with a gentle heat, add the water, filter, and keep in a well stoppered bottle.

5TH PROCESS.—*Staining in Aniline Green*.—The carmine dyed sections are to be removed from the alcohol and subjected to the action of an alcoholic solution of iodine green for at least twelve hours.

To prepare the green dye, take :—

Iodine Green Crystals ...	...	...	3 grains.
Absolute Alcohol ...	...	...	1 ounce.

Crush the crystals in a mortar, dissolve the powder in the alcohol, filter, and keep in a well-stoppered bottle.

6TH PROCESS.—*Mounting the sections*.—On removal from the green reagent, the sections must be rapidly rinsed in alcohol (either absolute alcohol or rectified spirit); they must not be left in the alcohol for more than two minutes, because the green stain is liable to be washed out. Previous to mounting them in canada balsam or dammar solution, they should be floated on to the surface of a watch glass full of oil of cloves, until they become translucent and sink to the bottom of the oil. Cajeput

oil may be used instead of oil of cloves ; they may be placed in this last for an hour, transferred to spirits of turpentine, and, after a short soaking, mounted in canada balsam or dammar solution.

Vegetable sections may be stained in a great variety of ways, all of them yielding beautiful results, illustrative of the special details which the manipulator may desire to demonstrate. We refer here to the methods employed in the study of the morphology of the cells, in revealing and exclusively staining their nuclei, nucleoli, etc. ; processes by means of which the various parts of the cell contents are determined and shown by means of microscopical analysis, and the general application of the microscope to botanical investigations. All these we must content ourselves by merely indicating in a notice of some of the more important papers and works upon the subject.

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ANSWERS TO CORRESPONDENTS.

All communications should be addressed to the Editor, MR. ARTHUR C. COLE, St. Domingo House, Oxford Gardens, Notting Hill, London, W.

All notices, letters, and advertisements should reach the Editor not later than Tuesday morning in each week, and should be written only on one side of each sheet of paper. Attention to these details will save delay.

PATHOLOGIST.—No. We have no intention to take up your subject, although there may be plenty of room for a journal such as you suggest.

CELL STAINING.—Use a half per cent. Solution of Gold Chloride, letting the sections remain in for an hour and-a-half. Your sections must be very thin and evenly cut.

H.B.R.—Much obliged for the hint, which you will see has been adopted in this issue.

CAMBRIDGE.—We are open to all feasible suggestions, and if you will send up your list of desiderata we will give it our best attention. Bone is our next subject.

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HUMAN BONE.

T. S. Compact Tissue of Shaft of a Long Bone.

× 50.

Etymology.—BONE, n. [A-S. *bân*, O.S. and Sw. *bên*, Dan. and D. *been*, Icel. and Ger. *bein*, Goth. *bain*, bone and leg; Lat. *os*, *ossis*, Gr. *ὀστέον*, a bone.] (*Anatomy*), One of the connective tissues formed from the metamorphosed descendants of cartilage or connective tissue cells. It exhibits two typical structural phases:—1°. A number of cells with stellate ramifying processes, which anastomose freely with one another, are surrounded by a lamellar calcified matrix, and occur in the skeletal organs of all vertebrated animals. 2°. An apparently homogeneous matrix, traversed by numerous approximately parallel wavy cell processes, which secrete around them a calcified membrane, the cells from which these processes originate do not enter into the composition of the tissue, but persist immediately outside of it. This kind of osseous tissue is found in the skeleton of many fishes, and the dental organs of all the *Vertebrata*.

Bone is an exceedingly hard, tough, and elastic structure, and eminently suited as a skeletal support for the limbs and trunk, and for shielding delicate organs, such as the brain and spinal cord. In these situations it occurs in all the vertebrated animals. Its hardness is due to a calcareous deposit, which is intimately associated with its fibrous tissue; to this latter it owes its toughness and elasticity. The calcareous material may be removed by maceration in dilute acids, which leave the form of the bone intact, and enable us to make out its fibrous character, for it then has the consistence of cartilage (in consequence of which it has been inappropriately termed *bonecartilage* or *ossein*), and can be sliced or teased out like an ordinary soft tissue. The fibrous element of the bone may be removed by ignition, when, although the shape of the bone remains unaltered, the calcareous matter alone remains as a brittle and friable mass.

DESCRIPTION.

Bones are classified by anatomists in accordance with their external forms as *long* or *cylindrical*, *short* or *irregular*, and *flat* or *tabular*. Their texture permits of a twofold division into *dense* or *compact*, and *spongy* or *cancellated* tissues; but a minute examination with a lens shows that there is no essential difference between these two kinds of bone, and that it is rather one of degree than of kind, for they gradually merge into one another. If a vertical section be made through a long bone such as the humerus or femur, it will be seen that it contains an irregular hollow

central space termed the *medullary canal* surrounded by cancellous, which towards the periphery passes into compact tissue. It may also be observed that the dense bone forms a thicker layer at the middle of the shaft, and gradually thins away towards the extremities, where it entirely ceases to exist, and gives place to caps of epiphysal cartilage. The cancellous tissue, on the other hand, forms the entire articular ends. In all these arrangements we see a combination for the providing of the greatest possible strength with a minimum of matter; the compact tissue is thickest in that part of the shaft (the middle) which is subjected to the greatest leverage strain, and the tubular character of the bone endows it with lightness and a capability of resisting external forces more effectually than a solid arrangement of the same amount of osseous tissue. The short or irregular bones are formed of cancellous, with only a superficial coat of compact tissue (*e.g.* in the carpal, tarsal, and other bones). Flat or tabular bones, such as those of the skull, consist of an internal spongy substance or *diplœ*, covered externally by a thin lamina of very hard compact bone, termed the *vitreous layers* by GLASTAFELN.

In 1838 SCHWANN first enunciated the great morphological law that animal tissues, however diverse in structure or function, are, like those of plants (as first shown by SCHLEIDEN*), built up of cells. He says** “*that there is one universal principle for their development, and that principle is the formation of cells.*” Now, it is very difficult for us to imagine, at first, that the transverse section of dense bone before us is in reality an aggregate of cells; yet a study of the development of bone, and a right appreciation of the signification of the term cell, as defined by RUTHERFORD†, compels us to accept Schwann’s statement here. The section under consideration exhibits a number of large apertures, which are the transverse sections of a series of channels termed *haversian canals* (after their discoverer CLOPTON HAVERS); around these are concentrically arranged layers of tissue termed *lamellæ*, between which may be seen somewhat compressed ellipsoidal spaces, the *lacunæ*, from which minute canals, the *canaliculi* radiate. In some cases spaces larger than the haversian canals obtain, and are either devoid of, or possess, but few lamellæ around them; they occur most frequently in young and rapidly growing bone, but TOMES and DE MORGAN‡ have shown that they may be found at all periods of life. These *haversian spaces* usually become haversian canals by the deposition within them of bony lamellæ; the fixing of the bone corpuscles in concentric series forming the lacunæ. The growth takes place in the haversian spaces from without inwards, and the *haversian system* thus formed may be regular or irregular in shape according to two variables, viz., the original form of the haversian space, and the growth inwards along the lines of least resistance. Each haversian system thus constituted is composed of a bony cylinder made up of layers of lamellæ,

*In Müller’s Archiv, 1838, p. 137.

**Sydenham Society’s translation of Schwann’s *Mikroskopische Untersuchungen*, London, 1847, p. 165.

†A Text-Book of Physiology, Edinburgh, 1880, pp. 27-30.

‡Philosophical Transactions, London, 1853, part i, p. 109, etc.

lacunæ, and their canaliculi; and the cylinders generally lie side by side along the bone in the direction of greatest strain.

So far we have fully considered the general aspect of our section of unsoftened bone. To fully understand the structure of bone, recourse must be had to decalcifying and other methods of manipulation, and longitudinal as well as transverse sections ought to be studied.

THE MEGASCOPIC AND MICROSCOPIC CHARACTERS OF BONE.—We have already alluded to the arrangements of dense and spongy tissue in bones. With the aid of a simple lens these can be made out more distinctly, and if a longitudinal section of a long bone be examined, its haversian canals may be seen to consist of a series of longitudinal and somewhat parallel passages which anastomose obliquely with one another, and have an average diameter of from 112.8μ to 14.9μ with extremes on both sides*, they open both on the surface of the bone and internally by wide funnel shaped apertures. If a softened section of bone be examined, the haversian canals and spaces are seen to contain bloodvessels, connective tissue, &c., which enter the bone obliquely from the *periosteum*—its vascular investing membrane. The medullary canal and cancelli are chiefly filled with marrow, bloodvessels, and connective tissue.

THE LACUNÆ.—A thin section of unsoftened bone examined with powers of from 50 to 800 diameters, shows the lacunæ to be ellipsoidal compressed cell-spaces with a length of 18.1μ — 51.4μ , a breadth of 6.8μ — 13.5μ and a depth of 4.5μ — 9μ , (FREY, *loc. cit.*). A section of softened bone magnified about 400 diameters exhibits the *bone corpuscles* within the lacunæ as nucleated cells without processes (BEALE).

THE CANALICULI are minute, branched, tortuous, anastomosing canals which connect neighbouring lacunæ. They can be made out in sections of dry unsoftened bone with a power of about 50 diameters; but it requires a magnifying power of from 800—1,200 diameters to disclose all their characteristics. They penetrate the calcified matrix of the bone, radiating in all directions from the lacunæ; their outer walls appear to consist of a calcified membrane which differs from the matrix of the bone and is a continuation of a similar structure which lines the lacunæ. VIRCHOW is of opinion that the canaliculi serve as lymph channels for the irrigation and nutrition of the bone corpuscles and osseous tissue generally. The canaliculi of each haversian system anastomose freely with one another and sometimes with those of neighbouring systems, but they more generally bend back into their own system, the “*recurrent canaliculi*” of RANVIER.

THE MATRIX of bone, like that of cartilage, appears to have a dual character. It consists of:—1° A delicate, evidently calcified, membrane lining the lacunæ and canaliculi (DONDERS and VIRCHOW†). 2° A calcified fibrous tissue arranged in the form of concentric lamellæ. The lamellæ can be made out most clearly in decalcified bone, but they may

*The Histology and Histochemistry of Man by HEINRICH FREY, translated by ARTHUR E. J. BARKER, London, 1874, p. 240.

The Greek letter μ is here used in its ordinary technical sense to signify *micromillimetre*. $1\mu = 0.0000397$ inch.

† Verhandlungen der physikal-medizin. Gesellschaft zu Würzburg, 1850, p. 193.

also be observed in sections of unsoftened bone. They were first discovered by SHARPEY,* who describes them as consisting of a fine network of transparent fibres, which coalesce at their intersections. The lamellæ may be readily stripped off from the surface of a long bone, which has been decalcified. Magnified about 400 diameters, the fine reticulum can be made out, and every here and there are closely set minute pores, which represent canaliculi, torn across; occasionally, larger apertures occur, these are the sockets out of which certain fibres, the *perforating fibres of SHARPEY*† have been forced. The lamellæ have between them an interstitial cementing substance which appears to be the seat of the calcareous deposition of the osseous tissue. A transverse section of dry unsoftened bone highly magnified, has a granular appearance, which is due to the alternating layers of lamellæ of unequal density, and interstitial cementing substance, as much as to the deposit of calcareous particles which also probably impregnate the lamellæ. The lacunæ are disposed in concentric series between the lamellæ, of which there are generally from two to five between neighbouring lacunæ.

Between the haversian systems in our section, may be seen *intermediate lamellæ*. These appear to be portions of the lamellæ of something larger than haversian lamellæ, although occasionally they are formed from haversian systems. They usually result as the products of absorption and encroachment by the haversian canals, on the *peripheric lamellæ* of the bone, *i.e.*, lamellæ which were originally formed immediately under and by the periosteum. Other lamellæ also occur in bone: in the medullary region these are essentially similar to those already described, but from their position are termed *cancellous lamellæ*. The intermediate and peripheric lamellæ of bone are then original growths. The haversian and cancellous lamellæ, on the other hand, are secondary formations which take place in haversian and medullary spaces formed by the absorption of the bone.

METHODS OF PREPARATION.

PRELIMINARY.—The fresh bone cut into pieces should be macerated in water for some months, until all traces of soft parts have been removed. To accelerate the maceration, and make sure of obtaining a thoroughly cleansed bone, the process should be conducted in a room at the ordinary summer temperature, and the water should be changed about once a week. The bone must not be permitted to dry before maceration, or else it will be indelibly stained with grease from the marrow. Where it is desirable, however, to cut sections of bones which have not been well macerated, they may be cleansed tolerably well by soaking slices in ether for about twenty-four hours, and then washing them thoroughly in water. If the bone contains a large amount of cancellous tissue, it should be soaked in a strong solution of gum until it is quite saturated with it, then hardened for a day in methylated spirit, and set aside to dry. Thin slices (from 1-8th to 1-10th inch) may then be cut off by means of a fine saw in any desired direction, and it will be found in the case of cancellated tissue with hardened gum, that the cancelli are supported *in situ* by the gum.

* Quain's Elements of Anatomy, London, 8th Edition, 1876, p. 86.

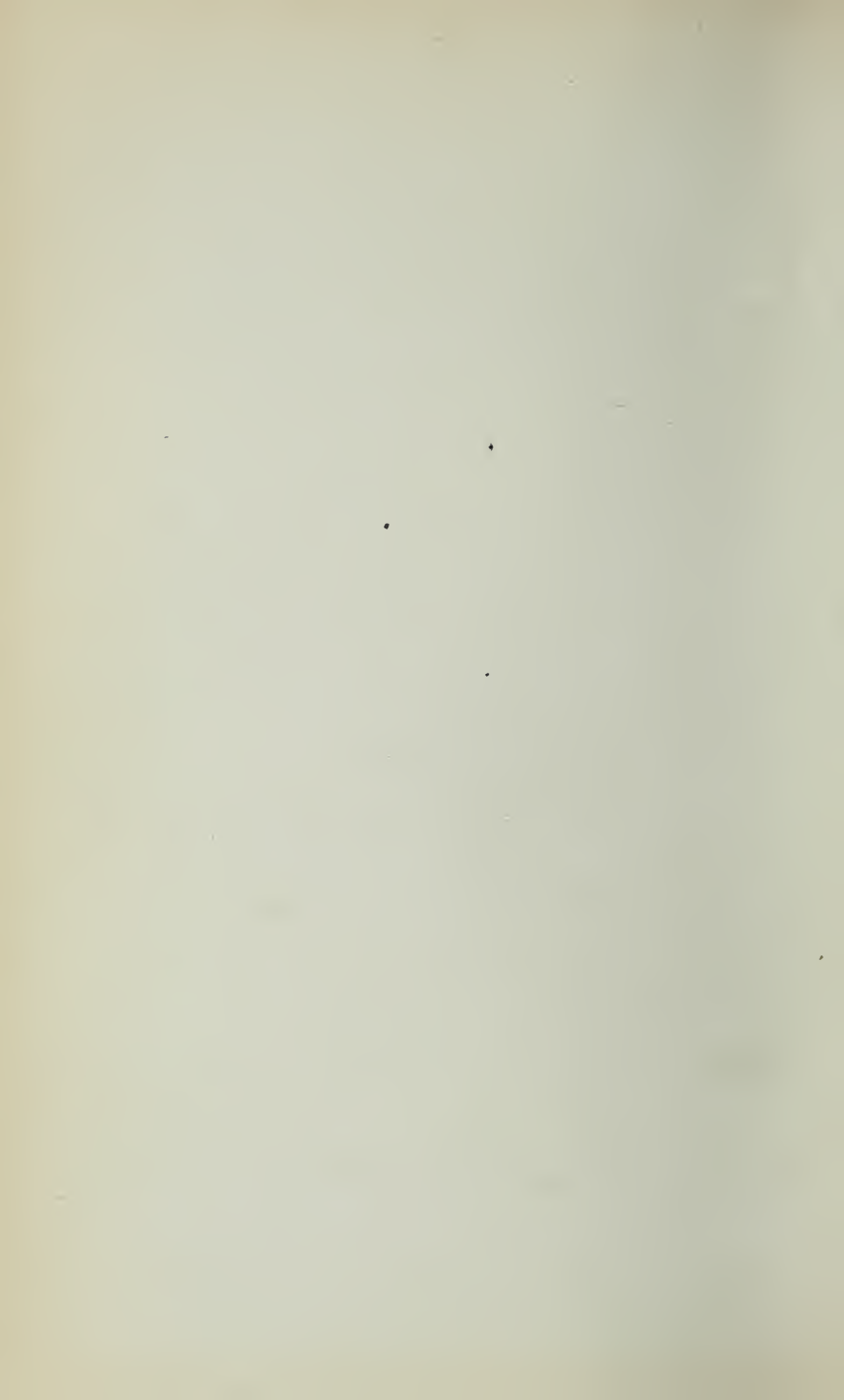
† Quain's Elements of Anatomy, London, 8th Edition, 1876, pp. 87-89.



del.ad.nat.

J.W.Watson, del. et lith.

TRANSVERSE SECTION OF BONE
Compact Tissue of Human Clavicle
X 50



1ST PROCESS.—The slices thus obtained must be ground perfectly flat and smooth on one side. This can be best effected on a fine grained thoroughly flat Water-of-Ayr stone or Turkey stone. If slices with cancellous tissue supported by gum are to be ground, methylated spirit should be used with the stone; in other cases, water suffices. It will be learned that the slice of bone can have its surface rendered perfectly flat and even polished on the stones mentioned.

2ND PROCESS.—The flat smooth surface of the slice must be fixed on to a stout slip of glass, as follows:—Place a few drops of old canada balsam on a slip of glass, heat it over a spirit or bunsen flame until the balsam is rendered sufficiently hard yet tough enough to fasten the section to the glass on cooling; this may be tested by removing a small portion of the balsam and allowing it to cool between the thumb and finger; it may be considered sufficiently baked if the balsam becomes just hard on cooling. Precautions should be taken not to overbake the balsam, as it then becomes friable, and, therefore, useless as a cement. A little practice will enable anybody to judge when the balsam should be removed from over the flame, by merely noting its appearance, without going to the trouble of testing it every time. The polished surface of the slice must be applied to the hardened balsam *as it is getting cool*, and the superfluous balsam between it and the glass slip, pressed out to the exclusion of bubbles of air. The balsam thus squeezed out ought to be carefully removed and the slide laid aside, under a clip, if necessary, until it becomes perfectly cold. If these details are not strictly adhered to, and the slice is placed on the balsam whilst still hot, it will inevitably result in a destruction of the slice by warping; and if the superfluous balsam is not scraped away from the slide before it hardens, its removal after hardening may detach the slice from the glass slip; it is necessary to remove it because its presence retards the subsequent process of grinding, and harbours particles of grit and dirt, which may prove fatal to the section when it is being ground very thin. The process just described will effectually fasten the slice of bone to the glass slip.

3RD PROCESS.—The other side of the slice may now be ground down on the stone until it is reduced to the requisite degree of thinness. To ascertain this it should be frequently examined under the microscope.

4TH PROCESS.—The application of a gentle heat will be sufficient to detach the section, which should be thoroughly well washed in a watch glass full of benzol or soaked in ether to remove any traces of grease which may exist.

Bone sections thus prepared may be mounted dry, *i.e.*, in air; they may also be mounted in glycerine jelly, canada balsam, or dammar solution. Only thoroughly well macerated bones admit of dry mounting without having their beauty impaired. If they are slightly discoloured they should be mounted in glycerine jelly. Canada balsam and dammar solution are seldom used because they obliterate structure by rendering the bone sections too transparent.

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The literature connected with the subject of bone has become so extensive, that a list of the books and papers written would completely

overwhelm these pages ; nor is it our intention to compile such a catalogue. We merely satisfy ourselves by appending a list of such works as may prove useful to the student as a guide to further research, especially with regard to the vascular and nervous supply of bone, its chemistry, and developmental history.

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All notices, letters, and advertisements should reach the Editor not later than Tuesday morning in each week, and should be written only on one side of each sheet of paper. Attention to these details will save delay.

The Editor acknowledges the receipt of one or two complaints that the journal was delivered in a crushed condition, having been doubled up so as to permit of being pushed into letter boxes. He would be glad if subscribers would instruct their *postmen to deliver their parcels at the door, and not put them into the letter box*. This is in conformity with existing post office rules, and any postman infringing such rules is liable to punishment.

J.D.—Dr. Marsh on section cutting, published by Churchill, price 2/6, is a handy little book for those who wish to begin to cut their own sections.

“STUDIES IN MICROSCOPICAL SCIENCE.”

“WE have before us at this moment an interesting novel venture in microscopical science and literature. Mr. Arthur Cole, a gentleman with a well-acquired reputation for his exquisite microscopical preparations, has favoured us with the first number of “Studies in Microscopical Science,” (*a*) and which he intends, he tells us, to *issue weekly*, for the use of students, teachers, the medical profession, and others interested in the progress of microscopical and the allied sciences. The attempt here made to combine a practical and technical knowledge of histology is in every way commendable, and these “studies,” if carried out in the spirit in which they are begun, will no doubt prove of considerable value, not only to the student, but to the teacher, as a means of saving time. In addition to the letter-press description, which is full enough, without too much elaboration, we have a faithfully-executed coloured lithograph of the specimen under observation; and Mr. Cole engages to furnish regular subscribers, for comparison and study, with a microscopical preparation of the highest class and finished in the most perfect manner. In the present case the specimen is one of yellow fibro-cartilage from the pinna of the ear of the cow. It is shown magnified 333 diameters, double-stained in logwood and eosin. The descriptive part may be relied upon as in every way accurate. The differentiation of the structural elements, the shape of the cells, the matrix and other typical characters of the specimen are very fully considered. The methods of staining employed in the preparation of kindred sections as a means of study are given with a fulness that will give delight to the practical microscopist. An extended bibliography is added, and will afford the student a ready and very useful means of reference to those authors who have by their labours enriched and enhanced the bearing on literature of the subject.”—*Med: Press and Circular*.

“UNDER the title ‘Studies in Microscopical Science,’ Messrs. Baillière, Tindall & Cox have published the first of a series of papers, which form an entirely new departure in literary work. The ‘Studies’ are to be issued weekly, and will each consist of descriptive letterpress of some one microscopical object, of which an accurate and careful illustration will be presented, and at the same time also a prepared section of the object, cut and mounted by Mr. Arthur E. Cole, F.R.M.S., whose histological and other slides have obtained a world-wide celebrity. The first number of the work comprises an account of yellow fibro-cartilage, and for excellence and fidelity of execution the accompanying lithographic drawing is superior even to those contained in the best atlases. The section issued with the paper is, moreover, a very beautiful object, stained with hæmatoxylin and eosin, and promises well for the utility and popularity of the series.”—*Med: Press and Circular*.

T. S. MONOCOTYLEDONOUS STEM.

UMBRELLA PLANT.

(*CYPERUS ALTERNIFOLIUS*).

Stained Carmine and Iodine Green.

× 400 diameters.

Etymology.—*ΚΥΠΕΡΟΣ*, n. [Gr. *Κύπερος*, sedge]. (*Botany*), A genus of plants belonging to the order of sedges* (*Cyperaceæ*).

DESCRIPTION.

Cyperus alternifolius presents us with an example of the monocotyledonous stem, in which the arrangement of the tissues of the fibro-vascular bundles obtains in a manner at once typical of that class, and unique in the symmetry of their disposition. The double staining, too, has rendered the object one of surpassing beauty.

In the accompanying plate we have depicted a single fibro-vascular bundle surrounded by a parenchymatous ground tissue, which has been coloured red by the carmine dye in the preparation.

The lower part of the plate represents the inner side of the bundle with reference to the axis of the stem. The whole system is enclosed in a sheath of thick walled prosenchymatous cells, which have been stained green; it may be noticed that these cells form a thicker layer at the inner part of the bundle, *i.e.*, the lowermost portion shown on the lithograph; they thin off gradually on each side, and join an almost distinct bundle at the outer aspect (top of the plate) of the system. This sheath is not developed to the same extent in all the bundles of the stem, and in a great many plants consists of an inner and an outer portion without the lateral parietics. By some authors it is collectively looked upon as a modified portion of the ground tissue, but its tendency to form two distinct groups has led others to consider the inner bundle as a portion of the xylem, and the outer one homologous with the hard bast of the dicotyledonous bundle.

The *xylem portion* of the fibro-vascular bundle is seen in the illustration to be composed of two large vessels, laterally situated; they are partially encircled by cells, which in common with them are coloured green; included between them and the underlying layer of thick walled prosenchymatous cells already alluded to, are a number of cells and vessels of various shapes and sizes: amongst these we may note two or three, centrally situated, which are of superior size and exhibit clearly defined broad walls. A longitudinal section of the stem reveals that these are spiral

*See SIR J. D. HOOKER'S *Student's Flora of the British Islands*, 2nd edition, London, 1878, pp. 423, 430, 431.

and annular, and that the two very large ones are pitted vessels; it also shows that some of the elements lying immediately between the two large pitted ducts are smaller vessels with reticulated markings, and bordered pits, and that the cells which partially surround the largest vessels, and are interspersed amongst the other vessels, are parenchymatous in character; all of these elements are rendered green. Lastly, there are two subtriangular groups of thinner walled cells, which are coloured red, and lie on each side of the spiral and annular vessels; these are found to be parenchymatous wood cells. Very often a lacunar air space may be seen immediately below the median spiral and reticulated ducts surrounded by the thin walled wood cells; this has been formed by a rupture of the tissues during the growth of the bundle.

The phloëm portion. If we regard the upper part of the limiting layer of prosenchymatous cells as the hard bast of the phloëm, we should expect to find that the group of red coloured cells just below them represents the soft bast of the bundle, and such in reality is the case. The fact, however, that a careful scrutiny of the cells composing the entire sheath of this boundary layer, fails to establish a distinction into parts, makes it probable that the hard bast is undeveloped. In the soft bast the elements are readily seen to be larger and smaller, and a longitudinal section shows that the larger of these are chiefly sieve tubes, and the smaller form the bast-parenchyma. There is no cambium layer.

In our further consideration of the monocotyledonous stem, it is unnecessary for us to detail the whole life-history of the plant from its embryonic origin, as we have already, in treating of the dicotyledonous stem, given a resumé of the succession of events which obtain, with minor differences of detail, alike in both these classes of plants.

The processes of impregnation and fertilisation take place in a manner analogous to those in dicotyledons; the only structural differences we perceive between them at the stage when the seed is ripe and about to germinate, are that the embryo possesses a comparatively large endosperm, and but *one* sheathing cotyledon. Germination is preceded and accompanied by the absorption of the nutrient stores of the endosperm cells by the cotyledon, the lower portion of which elongates, and carries the embryo along with it downwards. The *radicle* descends, the *plumule* ascends, and the cotyledon having fulfilled its functions, is discarded with the rest of the seed (*graminæ*) as a sheathing scale, or flourishes temporarily in form of a leaf.

The *epidermis*, like that of dicotyledons, always forms the external limiting layer of the young stem, and its cell walls very often become charged with a siliceous deposit to such an extent as to assume an outwardly polished and vitreous aspect, as may be seen in the stems of sedges, grasses, palms, &c.

The *cortex* of the stem in the young plant consists of more or less regular polygonal parenchymatous cells, amongst which bast fibres and vessels, and greatly thickened cells and vessels sometimes occur; laticiferous vessels may also penetrate the cortical tissue, and when they contain raphides are termed utricular vessels. In the course of its growth it is separated from the intermediate tissue by a layer of actively growing cells which form a *temporary cambium zone*, in which the fibro-vascular



J.W. Watson, del. et lith.

J.W. Watson, del. et lith.

CYPERUS ALTERNIFOLIUS
T.S. Closed Fibro-vascular Bundle
X400

Watson & Son, Chromo-Lithogrs, Newhall St, Birm.

bundles are developed; it consequently happens that on the cessation of growth in this layer, that part of the stem loses its power of increasing radially, and the cambium zone becomes the seat of lignification.

The older botanists laboured under the impression that the *fibro-vascular* bundles were developed in the central part of the stem, and thence took an outward course into the leaves; under this mistaken notion they applied the term *endogen* to the monocotyledonous type of plant. In the case of dicotyledons we noted* that the procambium of the embryo, in the course of its development into permanent cells, forms a cambium layer which remains permanently active during the whole life of the plant, and gives rise thus to *open* fibro-vascular bundles. In monocotyledons, on the other hand, the procambium continues in its transformation into permanent tissue, until the whole of its cells are so changed, and the resultant fibro-vascular bundles are devoid of a meristem portion, and have therefore been termed *closed*.

The vascular bundles are seen, on a transverse section of the stem, to lie isolated in the fundamental tissue. At their inner side, towards the central axis of the stem, there is a group of prosenchymatous cells, which in many cases form a layer round the whole bundle, and which we have already noticed above. Next to this group, or lower portion of the layer, are the vessels and lignified cells, surrounded by and intermixed with the parenchyma of the xylem. Towards the outer aspect of the bundle a well defined group of thin walled sieve tubes, cells, and bast-parenchyma subsists, and above this comes a layer of thick walled prosenchymatous cells, which is either isolated or continues round the whole bundle.

The *xylem portion* of the fibro-vascular bundles may consist of parenchyma, prosenchyma, and vessels. The *parenchymatous cells* are comparatively thin and unligified, they are greatly elongated, and resemble ordinary prosenchymatous cells, from which, however, they may be readily distinguished by their greater delicacy, and the invariably horizontal septa which separate them from one another. The *prosenchymatous cells* are usually lignified, and possess a small number of oval bordered pits. The *vessels* are thickened by annular, dotted, pitted, reticulated, and spiral markings; the pitted vessels being usually the largest. Occasionally, isolated vascular cells occur in the xylem.

The *phloëm portion* of the fibro-vascular bundles is composed of parenchyma, prosenchyma, and sieve tubes. The *parenchymatous cells* obtain in the soft bast, and are similar, in all essential respects, to those of the xylem. The *prosenchymatous cells* form the hard bast, and we cannot detect any morphological difference between them and those of the xylem, although it has been observed by some authors that they are more pointed at their ends. The *sieve tubes* are found in the soft bast, and differ from those of dicotyledons by being usually devoid of lateral perforations; their septa are horizontal, and provided with sieve discs. Occasionally laticiferous vessels occur, and are generally to be found in the soft bast.

The fibro-vascular bundles traverse the stem in two principal ways:—
1°. In the *graminice* they preserve a parallel longitudinal course through

* See p. 12 of this journal.

the internodes of the culm, and become branched and bent at the nodes. 2°. In the vast majority of instances they grow inwards towards the centre of the stem, and then, bending outwards through the cortex, enter the leaves; in this course they gradually diminish in diameter, and on reaching the cambium sheath divide into two parts, one of which pierces the cortex to enter the leaf stalk, whilst the other continues in its original direction to join the next older bundle. On making a transverse section of the stem, we thus find that the central bundles are of greater diameter than the peripheral ones, a longitudinal section showing that the age of the bundles has not anything whatever to do with their position in the stem.

Anomalous forms of monocotyledonous stems occur chiefly amongst the *Liliaceæ* and allied orders. In the Dragon plant (*Dracæna Draco*) there is an increase in the diameter of the stem from year to year, and also a separable bark; the cortical layer remains soft, and the fibro-vascular bundles admit of a division into primary and secondary groups: the former are scattered in the central parenchyma without any arrangement, and are normal in structure, whilst a *false cambium* gives rise to an outer series of anastomosing secondary bundles, which are devoid of true vessels.*

The *fundamental tissue* remains in its primary parenchymatous condition throughout the life of the plant. In those plants which develop hollow stems, the pith becomes ruptured and decays; the disappearance of these central cells is attributed also to a partial resorption.

METHODS OF PREPARATION.

The method employed in the preparation of our section has already been fully detailed. See this journal, p. 14, *et sequentes*.

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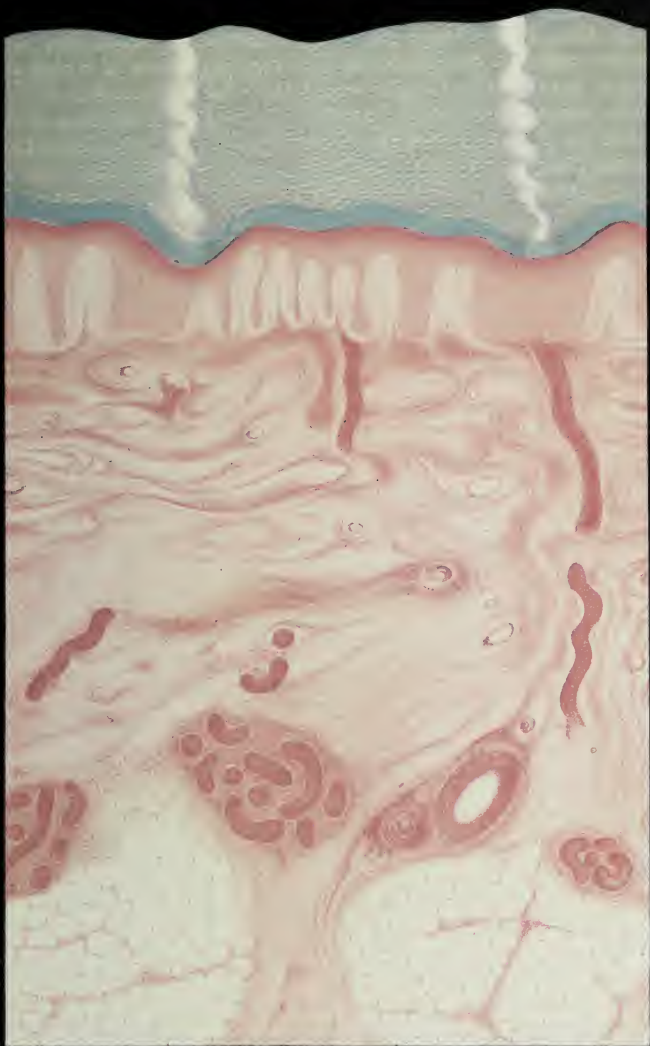
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*See MILLARDET, *Mem. de la Soc. des Sc. Nat. de Cherbourg*, XI., 1865.



del. ad. mat.

J.W. Watson, del. et lith.

V. S. HUMAN SKIN
Sole of Foot
X 65

Watson & Son, Chromo-Lithogrs, Newhall St, Birm.

HUMAN SKIN.

V. S., SOLE OF FOOT.

Stained Carmine and Sulph-indigotate of Soda.

× 65.

Etymology.—SKIN, *n.* [A-S. *scinn*, Icel. and Sw. *skinn*, Dan. *skind*, O.L. Ger. *schin*, *schinn*, Lat. *cutis*, Gr. δέρμα, gen. δέρματος, skin, from δέρειν, to skin flay]. (*Anatomy and Physiology*). In many of the lowest forms of animal life (*Protista*) the whole of the organism is so primitive in structure that the highest available power of the microscope utterly fails to demonstrate an external investing layer worthy of the name of integument; in some of them, however, a faint separation into *ecto*—and *endoplasm* occurs. As we ascend in the scale of life, and observe some of the simpler *Metazoa*, we find a distinct outer layer of cells (*ectoderm*) fulfilling the functions of an integument, provided with accessory organs for special purposes (*Hydrozoa*, etc.), secreting a hard protective membrane (*Arthropoda*), a calcareous outer shell (*Mollusca*), or a soft test (*Ascidia*). In the hard test of the *Echinodermata* the integument owes its origin to the incorporation of the *mesoderm* with the *ectoderm* in the formation of an intricate areolar calcified tissue. In the higher forms of animal life (*Vertebrata*) the skin admits of a rough division into two parts, the *cuticle* or *epidermis*, and the *cutis vera*, *corium*, or *dermis*. The embryonic *blastoderm* which results from the cleavage of the vitelline substance of the fertilised ovum very early subdivides into two layers; the *mucous stratum* or *hypoblast*, and the *serous stratum* or *epiblast*. It is from a part of the epiblast that the epidermis of the skin is developed. A third germinal layer, called the *intermediate stratum* or *mesoblast*, makes its appearance between the other two, and gives rise to the *corium* of the skin. Both of these elements may become the seat of complex chemical and structural changes destined to perform the functions of a protective, tactile, excretory, and absorbing organ.

In the lowest class of undoubted *Vertebrata* (*Pisces*) the epidermis persists as a soft delicate membrane, whilst the corium develops in all Fishes, except the two lowest orders (*Pharyngobranchii* and *Marsipobranchii*) numerous lamellar calcified plates (*scales*), which in some take on the characters of cartilage and true bone (*Accipenser*, *Scapirhynchus*), whilst in others they exhibit the textures of true teeth arranged in linear superposed series (the *placoid scales* of the Sharks and Rays, and the fossil *ichthyodorulites*). In all Fishes the deeper layers of the skin of the *fin-rays* becomes peculiarly and characteristically modified.

The integument of the *Amphibia* remains soft throughout, and develops in many of them superficial glands and contractile pigment cells of great

age is scarcely one-half as deep as in the adult. The cuticle consists principally of two layers of stratified squamous epithelium, the *horny layer* and the *soft layer*; the horny layer varies in thickness from 0·0347—2·26mm., whilst the soft layer, which is more constant in its depth, ranges from 0·0347—0·1128mm. (FREY).

The epithelial cells proliferate in the lower part of the soft layer, where the nuclei of the cells may be seen undergoing division, and are forced upwards into the horny layer, to give place to the multiplication which goes on below. In the course of this upward passage, they are changed in character; they increase in size, their protoplasmic contents dwindle gradually away, whilst their cell walls become thicker and cornified; their nuclei may vanish altogether, and they are finally removed from the surface of the skin, as scaly plates, by friction.

Although it thus appears, from developmental considerations, that no primary distinction can be drawn between the different parts of the epidermis, the morphology of its cells, and the functions which they perform, have led anatomists to distinguish them into four layers:—(i.) An outer superficial layer, the *stratum corneum*, composed of a stratified zone; towards the superficial periphery of the skin its cells become quite flattened, and most of them lose their nuclei. (ii.) The *stratum lucidum* of SCHRÖN, consisting of a narrow, apparently homogeneous, obscurely striated band of horny cells, in which staff-shaped nuclei may be detected. (iii.) The *granular layer* of LANGERHANS, which constitutes the uppermost layer of the soft part of the epidermis, and is made up of somewhat flattened, spindle-shaped cells, with distinct large nuclei; the protoplasmic contents of each cell exhibit numerous granular masses, which are largest near the nucleus. (iv.) The *rete Malpighii*, or *rete mucosum*, constituted by a layer of columnar cells, with large oval nuclei, closely apposed to the papillary layer of the skin, and surmounted by polyhedral cells of a similar nature. The cells in the lowest layers of the rete mucosum may be seen undergoing division; this is indicated by the division of their nuclei, but it is extremely difficult to trace the division of the cells themselves, which probably takes place by the formation of lines of vacuoles (RUTHERFORD). These cells are also peculiar in being connected with one another by fine filaments, as pointed out by BIZZOZERO and HEITZMANN. MAX SCHULTZE* maintained that the processes of these so-called “prickle” cells are interlocked with one another, and thus give rise to the denticulate appearance of the edges of the cells; but it has been shown by MARTYN† that these prickles are continuous at their apices. KLEIN** is of opinion that the prickles are fibrils uniting the substance of contiguous cells, which he describes as a very dense network. The most plausible explanation of the true significance of these cells, however, is that accepted by RUTHERFORD‡ who states that RANVIER’s method of hardening in osmic acid§ “reveals the contour of the cell, marked by a line of rounded spaces between which the so-called ‘prickles’ stretch as bridges between the

* *Virchow's Archiv*, Bd. 20, s. 260.

† *Monthly Microsc. Journ.*, London, xvi, p. 59.

** *Atlas of Histology*, London, 1880, p. 16.

‡ *A Text Book of Physiology*, Edinburgh, 1880, pp. 66-67.

§ *Traité Technique d'Histologie*, Paris, 1875, p. 261.

cells;" he goes on to say that "the prickles seen on detached cells apparently result from the rupture of these bridges by mechanical methods employed for isolating the cells," and that "the spaces between the bridges are probably channels through which the lymph permeates from the subjacent capillaries to nourish the growing cells of the *rete mucosum*." The lowest cells of the Malpighian layer of the epidermis are closely attached to the corium underneath, and their downward processes dip into the fibrous tissue of the dermis; in the neighbourhood of the sweat glands these cells often dip down around the tubules to a considerable extent in the form of an investing layer of epithelium.

The cells of the epidermis vary in size from 0.0425—0.0750 mm., those of the deepest layers of the *rete mucosum*, and to a lesser extent its other strata, contain pigment granules which usually aggregate around their nuclei.

The *true skin*, *cutis vera*, *derma*, or *corium* consists of a highly vascular and nervous structure of connective tissue, the uppermost portion of which is raised up into numerous prominences or *papille*; its lower layers gradually pass into a loose *subcutaneous areolar tissue* which contains clusters of fat cells (hence the name *panniculus adiposus* which has been applied to it) and lodges the convoluted tubules of the sweat glands, &c. The tissue of the corium is composed chiefly of a network of white fibrous tissue largely intermixed with elastic fibres, and a complicated system of connective tissue corpuscles with reticularly anastomosing processes, together with numerous lymphoid independent cells. In the papillary and highest layers, the fibres are very fine, closely packed, and appear to form a homogeneous stratum; the limitary layer thus formed is the *immediate membrane* of HENLE, or the *basement membrane* of TODD and BOWMAN. Lower down the fibres are coarser and more loosely interlaced, and pass by a gradual transition into the subcutaneous areolar tissue.

Unstriped muscular fibres occur in the skin in the vicinity of hairs; they rise from the superficial layer of the corium and pass obliquely downwards to be inserted into the outer portion of the hair follicle on that side to which the hair slopes. Similar circularly disposed fibres have also been described as existing immediately around the follicles, and in certain situations (the nipples and their areolæ, the penis, the *tunica dartos* of the scrotum, and the perineum) obtain in the subcutaneous tissue. J. NEUMANN has described bands of non-striped muscular fibres which pass from the upper part of the cutis into the panniculus adiposus, and branch freely in all directions; and numerous fibres have been traced below the sweat glands and tactile corpuscles, etc. Striated muscular fibres do not occur in the skin; in certain parts they merely attach it to subjacent structures, *e.g.*, the *orbicularis oris*, the cutaneous muscles of the face and neck, the *panniculus carnosus*, etc.

The papillæ of the corium may be either simple, or compound, *i.e.*, cleft into two or more parts; they vary very considerably in size, shape, and numbers in different parts of the body. The largest papillæ are to be found on the volar side of the hand, the plantar region of the foot,

and the nipple; they measure from 0.1505—0.23mm. in length, and may be conical tongue shaped, or altogether irregular; in the skin of the face they may be reduced to mere elevations which range from 0.0451—0.0377 mm. and less (FREY). In the skin of the palm and that of the sole they are arranged in linear series, and give rise to the well-known ridges and furrows of those parts; in the ridges they are usually placed in a double row, and the furrows are caused by the dipping down of the epithelium between these rows; at short intervals the ridges are marked by a number of small depressions, which are the orifices of the sudatory glands. In other parts of the body the papillæ are indefinitely arranged and in all parts, more notably the back of the hand, produce numerous intersecting furrows and isolated ridges.

The corium is very richly supplied with bloodvessels which are derived from the vessels of the subcutaneous tissue, in which they form meshes around the clusters of fat cells, hair follicles, and sweat glands; they pass into the corium, where they form a very intricate system of capillaries, which spread out in a horizontal direction, and supply most of the papillæ with capillary loops. The researches of TEICHMANN and NEUMANN have revealed a very complicated lymphatic system in the skin; it consists of a dense meshwork of large vessels containing valves, in the subcutaneous tissue, passing into a finer plexus of valveless vessels in the corium, which may give off diverticula, and enter the papillæ either as simple tubes or as loops. The nutrition of the rete mucosum by means of the lacunar system of the so-called "prickle" cells has already been alluded to.

The nervous system of the skin finds expression in numerous plexuses, from which their branches divide and subdivide as they pass towards the papillary layer of the corium, to terminate finally in either bulbous extremities or in very delicate fibrils in the *rete mucosum*. They supply the glands and hairs of the skin, and very often end in peculiar terminal organs, which have been called *Pacinian bodies*, *tactile corpuscles*, and *end bulbs*. The Pacinian bodies are to be met with in the subcutaneous tissue, the tactile corpuscles occur in special vascular or non-vascular portions of vascular papillæ in the palm, sole, and many other parts of the body, whilst the end bulbs are to be found on some of the papillæ of the red portion of the lips, the *glans penis* and the *glans clitoridis*. As may be expected, the nervous supply is always found to be directly proportional to the sensibility of the part, and thus varies to a considerable extent in different regions.

METHODS OF PREPARATION.

LISTER'S METHOD FOR THE OBSERVATION OF THE "PRICKLE" CELLS.—Place the foot in hot water for about half an hour, scrape off the epidermis, and macerate it for some time in a $\frac{1}{6}$ per cent solution of potassium bichromate. On teasing the tissue thus prepared the prickle cells will be rendered apparent under a magnifying power of from 700-1000 diameters. Thin sections of skin made from pieces which have been hardened in a $\frac{1}{6}$ per cent. solution of potassium bichromate, with a few drops of carbolic acid in it, may also be teased out for the observation of

the prickle cells. The epidermic horny cells may be advantageously studied after soaking in a strong solution of potassium hydrate.

RANVIER'S METHOD.*—Inject a $\frac{1}{4}$ per cent. solution of osmic acid into the rete mucosum by means of a hypodermic syringe, introduced obliquely into the skin; cut out the piece thus prepared, and harden it for a day or two in rectified spirit. Vertical sections may now be made and preserved in glycerine. It will be found on examination with a high power ($\times 700-1000$) that the osmic acid has stained the protoplasm of the prickle cells a neutral tint, and reveals the lymph spaces which we have noted in our description. Osmic acid was introduced into histology as a hardening re-agent by MAX SCHULTZE; it may be obtained in the form of small glassy-looking particles in sealed tubes, but it is best procured as a 1 per cent. solution in distilled water. It should be kept in a well-stoppered bottle, and carefully protected from the light; its vapour is extremely irritating, especially to the nostrils, and as it is very poisonous it should be cautiously used. It is specially useful in hardening delicate tissues, such as embryos, etc., as it does not cause any great shrinkage of the tissue elements, and slightly darkens them, whilst it blackens particles of a fatty nature. To harden tissues they should be placed in it according to their requirements, ranging from a few minutes to forty-eight hours, then washed in distilled water, cut into sections, and mounted in a saturated solution of potassium acetate, or in glycerine.

STIRLING'S METHOD OF DIGESTION.†—The value of this method in the study of the skin depends upon the fact that digestion acts more rapidly upon some tissues than on others, and thus by partially changing or entirely removing certain structures, reveals the presence of others or renders them more conspicuous. Its partial action upon skin has the effect of causing the white fibrous tissue to swell up and become transparent, and thus permits of the study of the other elements. We cannot do better here than give Stirling's method in his own words:—"Make an *artificial gastric juice* by mixing 1 cc. of pure hydrochloric acid with 500 cc. of water, and add one gramme of pepsine, or a few drops of a glycerine extract of the gastric mucous membrane. It is well to keep the mixture at 38° c. for two or three hours before using it. The piece of skin to be digested is stretched over a small glass ring and firmly tied to it. It is then placed in some (200 cc.) of the digesting fluid, which is kept at a temperature of 38° C. in an ordinary water bath for a period varying from three to eight hours,—the time depending upon the age and size of the piece of skin. After partial digestion the skin is placed in water for twelve hours when it swells up and becomes extremely transparent. It may be kept most advantageously in a ten per cent. solution of common salt, or it may be hardened in one of the ordinary hardening fluids, and afterwards stained with logwood or carmine."

This method may be used with other tissues also, it has been employed successfully by BIRCH in the study of bone, and by KÜHNE in his researches on the structure of nerves.

* See *Traité Technique d'Histologie*, par LOUIS RANVIER, Paris, 1875, p. 261.

† *A Text Book of Practical Histology*, by W. STIRLING, London, 1881, pp. xxxiv-v. 92-3.

STAINING WITH CARMINE AND SULPH-INDIGOTATE OF SODA.

PRELIMINARY.—*Hardening the Skin*.—Small pieces of the skin cut from various parts of the body should be placed in a solution of chromic acid and spirit for about 18 hours, the fluid should then be renewed and the tissue allowed to remain in it for from 10 to 30 days; they should then be removed to rectified spirit for a few days when they will be found sufficiently hardened to be cut in the microtome in a piece of carrot, imbedded in paraffin, or frozen in gum solution.

To make the *Chromic Acid and Spirit Solution** :—"Dissolve 1 gramme chromic acid in 20 cc. water, and *slowly add it* to 180 cc. rectified spirit."

1ST PROCESS.—*Staining in Carmine*.—The sections are to be placed in an ammoniacal solution of carmine for from 5 to 10 minutes, or until they are thoroughly stained and then washed in rectified or methylated spirit.

Take of Carmine.....dr. i
Ammonia (fort.).....dr. ii.

(A). Dissolve the carmine in the ammonia with the aid of a gentle heat and filter. (B). Make a saturated solution of borax in distilled water and filter it. Add A to B, filter.

2ND PROCESS.—Remove the sections from the spirit into the following solution for about 10 minutes :—To five parts methylated spirit add one part of pure hydrochloric acid. Wash in strong rectified or methylated spirit, and allow the sections to remain in this for an hour or two, so that all trace of the acid may be removed.

3RD PROCESS.—*Staining in Sulph-indigotate of Soda*.—Transfer the sections into a large quantity (two or three ounces) of the following, for from six to eight hours :—Add two or three drops of a saturated solution of sulph-indigotate of soda to one ounce of methylated spirit. This solution should be made as required, from time to time.

4TH PROCESS.—*Mounting the Sections*.—The directions given in this journal at pp. 6, 15, and 16, may be followed here, and the sections mounted in Canada balsam or dammar solution.

Sections of skin may be stained in logwood and picrocarmine* ; thus treated the horny layers of the epidermis are rendered yellow, the rete mucosum and sweat glands a logwood-tint, and the connective tissue, &c., red. They may also be stained with logwood and iodine-green, but we cannot recommend this method, as the green dye is very fugitive. For the time being, however, they make very beautiful preparations, the hard layers of the Epidermis are stained yellow, the rete mucosum, sweat glands, and nuclei of the fat cells and connective tissue corpuscles, green, and the fibres of the connective tissue red. The method of staining with gold chloride and osmic acid‡ has been employed for the purpose of demonstrating the tactile corpuscles and nerves of the skin.

* See RUTHERFORD, *Outlines of Practical Histology*, London, 2nd edition, 1876, p. 3.

‡ See this Journal, p. 6.

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del. ad. nat.

J.W. Watson, del. et lith.

PIKRITE
Inchcolm.
Firth of Forth.
X 25

Watson & Son Chromo-Lithogrs. Newhall St. Burn.

PIKRITE.

Inchcolm, Firth of Forth, Scotland.

× 25.

Etymology.—PIKRITE, *n.* Evidently so called because its green constituents, which sometimes take on a fibrous texture, cause it to resemble *picrolite*, a bitter fibrous variety of serpentine, of a green colour. [Gr. *πικρός*, bitter, and *λίθος*, stone].

DESCRIPTION.

Amongst the numerous rocks of igneous origin there are perhaps none which puzzle the petrologist so much in his attempts at a rational classification as the small group which seem to pass by a gradual transition into *serpentine*. Comparatively few such rocks have yet been discovered, but wherever the stratigraphical details have been worked out in conjunction with their mineralogical characters, they seem to establish the igneous origin of serpentine. Thus PICOT DE LA PEYROUSE* described a rock which occurs in masses around the Etang de Lherz, amongst veins of limestone, near Vicdessos, in the Eastern Pyrenees, which DELAMÉTHÉRIE** named *lherzolite* after its locality. According to DESCLOIZEAUX*** it consists of olivine, an infusible brown pyroxenic mineral, allied to hypersthene, a green fusible pyroxene, and numerous granules, with occasional octahedra of picotite disseminated through the rock.

DAMOUR† subsequently worked out its mineral constitution, and states it to be composed of olivine, enstatite, diopside, and picotite, which occur in abundance in the order just quoted, the olivine forming the greatest bulk of the rock. The investigations of VON LASLAUX‡, and, more recently, those of BONNEY††, have established that this rock becomes so metamorphosed in certain parts, that it is fully entitled to rank as a serpentine, and BONNEY is of opinion that it is of intrusive igneous origin; he goes further still, and states§ that the serpentine of the Lizard, in Cornwall, in which he has discovered decomposed olivine, enstatite, and picotite, is a metamorphosed intrusive lherzolite. Rocks which closely resemble lherzolite have been found in Norway, the Tyrol, the depart-

*Mem. Acad. Toulouse, iii, p. 410.

**Théorie de la Terre, 1797, T. ii, p. 281.

***Manuel de Mineralogie, I, p. 65, etc.

†Neues Jahrb. f. Min., 1863, p. 95, etc.

‡Elemente der Petrographie, Bonn, 1875.

††The lherzolite of Ariège, Geol. Mag., Decade II, Vol. IV, 1877, p. 59, et seq.

§On the Serpentine and Associated Rocks of the Lizard District, Q.J. Geol. Soc., Vol. XXXIII, p. 923, etc.

ment of Haute Loire, Nassau, the Fichtelgebirge, and many other places, and VON LASLAUX notices its occurrence in the form of olivine bombs in some basalts.

Nearly related to Ilherzolite, indeed so nearly in some instances, that F. SANDBERGER * regards it as a variety of that rock, is the *dunite* of F. VON HOCHSTETTER,† a rock which passes by gradual alteration into serpentine, and is composed of olivine and chromic-iron, with occasional crystals of diallage and enstatite, forming a crystalline aggregate of a grayish-green colour, and greasy vitreous lustre. It was first found in Dun Mountain near Nelson in New Zealand (whence its name) but has since been localised in the south of Spain and other places.

In 1866 TSCHERMAK ‡ described a rock which he called *pikrite*, and GÜMBEL under the same name characterised some of the rocks of the Fichtelgebirge. DANA,** under the head of observations on chrysolite notices a rock from Moravia, named *picryte*, which he describes as consisting half of chrysolite, along with felspar, diallage, hornblende, and magnetite, and PREYER, ZIRKEL, and VON LASLAUX all notice the rock in their petrological considerations next to Ilherzolite and dunite.

In its tendency to become transformed into serpentine, pikrite does resemble the two last named rocks, and it presents us with examples of undoubted volcanic rocks both in the form of coulées, and as intrusive masses. It has hitherto been found in only two localities in Scotland. It was first detected by GEIKIE in the form of a true lava-bed at Blackburn, near Bathgate, and afterwards as an intrusive mass in the Island of Inchcolm. GEIKIE*** describes the variety from Blackburn as a volcanic sheet of lava which solidified on the surface of the earth during the time when the older part of the carboniferous limestone series were accumulating in West Lothian. The rock is to be seen in Blackburn quarry only, and has been worked under the name of "lakestone" for several years, as a material used in the construction of the soles of ovens, for which purpose it is eminently adapted on account of its low thermal conductivity. The upper portion of the band is seen to be distinct from the lower part, and although no sharp line of demarcation can be drawn between them, a distinction is made by the workmen who reject the upper as too hard to be used, and utilise only the lower portion. The whole rock is traversed by irregular vertical veins of serpentine, chrysolite, and calcite, and a careful inspection shows a serpentinous basal part surmounted by a less altered upper band. GEIKIE's examination of the rock revealed the lower serpentine passing by gradual shades into a lighter more felspathic material, and from this he drew an important conclusion, viz.:—that the olivine, augite, and iron, of the original lava on account of their greater specific gravity settled in the largest proportion at the bottom of the bed, whilst it was yet sufficiently molten to permit of such segregation, and produced by their alteration the serpentine of the base,

* Neues Jahrb. f. Min., 1865, p. 449.

† Zeits. d. d. Geol. Ges., 1864, p. 341.

‡ Sitzungber d. k. Acad. in Wien, 8 März, 1866.

** A System of Mineralogy, London. 5th ed., 1881, p. 258.

*** On the Carboniferous Volcanic Rocks of the Basin of the Firth of Forth, Trans. Roy. Soc. Edin., 1879, p. 504, et seq.

whilst the lighter felspar predominates in the upper part, and has produced the pikrite; thus proving that the remarks of SCROPE on the arrangement of the minerals in modern lava flows, can be extended in their application to those of the palæozoic age.

The upper portion (pikrite) of the Blackburn rock is stated by GEIKIE* to give the following characters:—"Finely crystalline base of a dirty, blackish green colour, and a tolerably homogeneous but dull texture, showing many ill-defined greenish white points, apparently of decayed felspar with minute facettes, some of which are pyrite; fracture, splintery; hardness, 3 to 4." "It contains among its constituents a feeble quantity of a distinct glass which occurs occasionally in large interspaces, and then shows a dusty character, resolvable with a high power into exceedingly minute dark globules. The most abundant mineral is a colourless and tolerably fresh triclinic felspar. Next in amount is a pale yellowish transparent mineral in very small prisms, which seems to be augite, but of an unusual form. Some of these prisms, not exceeding $\cdot 0005$ of an inch in diameter, may be seen enclosed in the altered olivine. The latter mineral can be recognised in the form of crystals, from about $\cdot 03$ to $\cdot 10$ of an inch in length, completely serpentinised. They consist mainly of a pale delicate apple-green clouded and fibrous substance, which is bordered and traversed by strings of a bright grass green, sometimes of rich yellowish brown. But these olivines occur in much smaller quantity than in the lower part of the rock. Titaniferous iron or magnetite likewise appears as in that lower part, but also in less abundance. Apatite may be detected occasionally."

The pikrite of Inchcolm, which forms the subject of our illustration, occurs as an eminence at the south western part of the island, its upper surface is exposed and has evidently been laid bare by denudation; it overlies beds of hardened sandstone, limestone, and shale. The absence of any trace of vesicular and amygdaloidal structure, and the analogous condition of the volcanic rocks of the adjacent islands and neighbouring coast, indicate its probably intrusive character, and point to its contemporaneous carboniferous age. GEIKIE† in his notice of the rock says that it "is considerably fresher than that of Blackburn," and "examined under the microscope, it is seen to be by far the most beautiful rock in the basin of the Firth of Forth."

It is composed of olivine, a green alteration product, augite, a whitish fibrous zeolite, a few plates, and numerous grains of titaniferous iron, occasional scales of biotite, and a few crystals of apatite. GEIKIE** says that there is also a milky felspar, full of fissures, filled with decomposition products, but still showing traces of twin lamellation, which occupies a very subordinate place in the rock, but we have failed to detect this mineral in any of the sections which have come under our observation.

The OLIVINE, *n* [Fr. *olivine*, from Lat. *oliva*, olive, Gr. *ἐλαία* (*Min.*) An olive-green variety of chrysolite], constitutes by far the greatest bulk of the rock, and occurs in well defined crystals,‡ which are usually sur-

* Loc. cit., pp. 506, 507.

† Loc. cit., p. 507.

** Loc. cit., p. 507.

‡ See Analytical Chart.

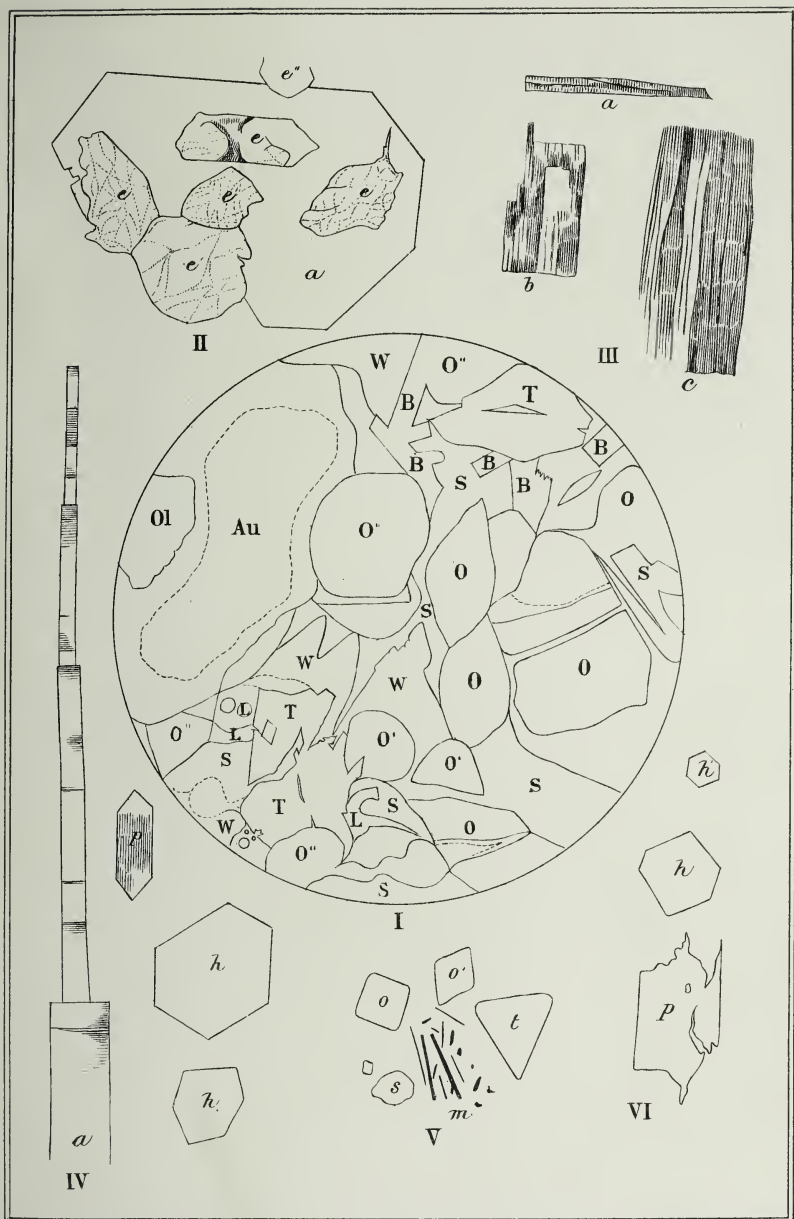
rounded by the green decomposition product, or enclosed in the crystals of augite. The sections of these crystals generally present elongated six-sided forms, although eight-sided and four-sided ones are by no means uncommon, and in some instances their outlines are altogether irregular, their angles also may sometimes be seen to be rounded off. Those enclosed within the augite are, as a rule, of small size, but are nevertheless very clearly defined, they range in length from $\cdot 0047$ — $\cdot 0458$ in., and in breadth from $\cdot 002$ — $\cdot 003$ in. The other larger crystals have a length of from $\cdot 120$ — $\cdot 037$ in., and a breadth of $\cdot 039$ — $\cdot 031$ in.* It has been observed that whilst the length of the crystals varies very largely their breadth seems to assume more constant dimensions. A few of the crystals have become changed to a reddish brown colour, and some of these may be seen under a power of about 100 diameters to exhibit a faint striation, and bear out the statement made by DANA† who attributes this change to the oxidation of the iron in the mineral, which is accompanied by a modification of its colour to a brownish or reddish-brown, may become iridescent, and split into laminae, so as to resemble a mica. But the vast majority of the crystals are traversed by irregular fissures, which do not bear any relation to their crystallographic forms, but seem to be altogether indefinite. It is evident that the greater number of these cracks have been produced during the slicing and grinding of the section; but, at all events, there are others which have not been thus caused, and may be recognised by the alteration which has taken place along their lines.

This change is seen to progress from the fissures into the substance of the crystal, and to superinduce a finely fibrous fringe at right angles to the lines from which they radiate, and the part so altered exhibits a honey-yellow colour. The borders of the crystals also become the seat of a similar change, and acquire a colour ranging from honey-yellow to a dirty green. Under powers of from 300 to 500 diameters these serpentine fissures are shown to be filled with a material of a brownish yellow colour, in which numerous minute acicular and granular opaque black microliths obtain, and are probably composed of titaniferous iron or magnetite. Minute spaces may also be seen here and there, but they are either empty or filled with gas. Fluid cavities do not occur in this olivine, and the cut surfaces of the crystals appear quite coarse and rough under a high power of the microscope. Under crossed Nicols the fresh portions of the crystals polarise in strong colours, and are doubly refractive, the altered parts continue unchanged throughout the rotation of the prisms.

The alteration products which surround most of the crystals of olivine vary in tints from a bright grass green to a rich emerald hue discoloured every here and there by a dirty brown or reddish brown which probably results from the decomposition of the iron both of the olivine and the titanoferrite. These limonitic discolourations may be seen surrounding many of the crystals of iron, and thus lead us to suppose that it is the

* These, and all other measurements given in this paper on the authority of the writer, admit of extremes on both sides, and especially for the crystals of olivine enclosed within the augite, which may be reduced to mere granular specks, even under a high magnifying power. In all cases they have been selected from over 300 accurate estimates.

† A System of Mineralogy, London, 1881, 5th ed., p. 258.



J. del. ad. nat.

J.W. Watson, del. et lith.

PIKRITE Analytical Chart.

result of their oxidation which gives rise to the brownish patches in the green groundwork. With a power of about 500 diameters every portion of this green material seems to be crowded with peculiar tufted fibrous structures, which radiate from centres of growth as it were, and in some portions small groups of minute colourless prisms are aggregated together which remind us strongly of the similar larger prisms of apatite which abound in these parts of the field. That the green substance is an alteration product of the olivine is easy to imagine, since the crystals of olivine may be seen to be insensibly invaded by it, both through their borders and by way of the serpentinous fissures already alluded to, and the investigations of DANA, to which we have already referred, warrant us in stating that the iron of the olivine, after having been oxidised, has been removed by the action of carbonated waters together with some of the magnesia, and that the result of this reaction has manifested itself in the formation of this green fibrous material, which we consider to be true serpentine. Our conclusion is, moreover, supported by the fact that we have detected a precisely similar texture in the undoubted serpentine of Clicker Tor in Cornwall, and in a beautiful specimen from Saxony, both of which bear traces of being the metamorphosed results of a rock allied to Ilherzolite. The green material polarises very feebly, the fibrous tufts become illuminated by pale bluish and grey tints, whilst the ground substance remains dark, phenomena which also obtain in the serpentines.

The AUGITE, (*a*) n. [Fr. *augite*, Lat. *augites*, Gr. *αυγίτες*, from *αυγε*, brightness.]

Next in abundance to the olivine, occurs as singularly fresh large crystals in irregular, angular, and subangular patches, with numerous longitudinally disposed parallel breaches, which impart a coarsely lamellar aspect to the mineral, and a multitude of indefinitely disposed cracks, resembling the fissures produced in a broken pane of glass, and evidently due to the mechanical methods of manipulation, occasionally well marked eight sided forms may be seen. The crystals average in length from .025—.083in., and give good cleavage angles of $87^{\circ} 5'$, and $92^{\circ} 5'$; their boundaries are in every case very sharply defined, and they vary from a pale claret tinge by occasionally shading off to an edge of purplish-brown and yellowish-brown. Besides the crystals of olivine they do not possess any enclosures, unless we regard a few minute rhombohedra and acicular and granular particles of iron as such, but these are always closely contiguous, if not embraced within the endomorphs of olivine; these last exhibit all the details of the larger crystals which we have already fully described. The appearances we have noted, and the absence of any zony lines of accretion, or of any modification in places where it is in contact with the highly metamorphosed greenish fibrous serpentine, altered chloritic product, or other decomposed constituent, lead us to surmise that the crystallisation of the augite must have been the final phase in the formation of the rock texture.

With polarised light under a power of 70 diameters, most of the crystals are seen to be very feebly dichroic, and appear perfectly dark under fully crossed Nicols. A few of them, however (by no means thick sections) are strongly dichroic, changing from a brilliant azure blue through a rich purple and neutral tint to a golden orange under con-

pletely polarised light. One specially thin section did not exhibit the purple coloration, but changed from a delicate blue through neutral tint to a pale orange. Examined under ordinary light, we are predisposed to detect a slight excess of yellow and purple in these augites, and thus to add evidence to the generalisation arrived at by ALLPORT in his extended observations on this mineral in his admirable memoir.*

A whitish milky decomposition product, with obscurely parallel lines, fills most of the interspaces between the olivine, green product, and the augite; it is crowded with a meshwork of cracks, around which a high power reveals a finely granular cloudy texture; it does not contain any endomorphs or cavities. Other similar aggregates of a finely granular aspect seem to merge gradually into certain patches of the green serpentinitoid material, and a few brownish white fibrous tufts may be seen filling up some of the cavities, and are probably of a zeolitic nature for they exhibit a dark cross between crossed Nicols, and the cross remains stationary on a horizontal rotation of the section. The white decomposition product is unaffected by polarised light except in certain places where indefinite parallel bands of colour appear, and seem to indicate the vestiges of what once was a felspar exhibiting twin lamellation.

TITANIFEROUS IRON, (*t*).—**TITANIFEROUS**, *a* [N. Lat. *titanium*, so called from the Titans; Lat. *titani*, or *titanes*, Gr. *Τιτᾶνες*, the sons of the earth, and Lat. *ferre*, to bear; Fr. *titanifère*]. Containing titanium. This mineral occurs in the form of occasional large broken plates, in the section, which bear traces of an hexagonal form and numerous well marked small rhombohedral sections, varying in size from .033—.0024 in. The larger plates are situated chiefly between the crystals of olivine and the green matter, and never in the augite; the smaller forms abound in the same parts, and also obtain to a less extent within the crystals of olivine, always, however, at the lines of fissure of yellow or green alteration product, and especially in those portions which encroach on the borders of the crystals; rarely in the white decomposition products, and only exceptionally in the augite, and then, as has already been pointed out, immediately contiguous to the enclosures of olivine. They are perfectly black and opaque and exhibit a dull metallic lustre when viewed under condensed and transmitted light at the same time. Polarised light, of course, is not of much value here; we may note in passing, however, that a few of the crystals in one of the sections examined, had either undergone some change, or what is more probable had been ground so excessively thin, that they appeared of a reddish brown colour by transmitted light, and became alternately opaque and translucent with polarised light, some being brilliantly lighted under crossed Nicols and others quite obscure, whilst on a revolution of the polariser the illuminated ones gradually became black and then suddenly resumed their ordinary hue, and the obscure ones were rendered apparent. We say that it is probable that these crystals had been ground very thin, because they preserve their hexagonal contours with wonderful distinctness, and in one case we observed the opaque black part passing gradually to the translucent reddish portion. Very many of the iron crystals are surrounded by a reddish discolouration; in some of these

* On the microscopic structure and composition of British Carboniferous Dolerites, Q. J. Geol. Soc., Vol. xxx, p. 536.

cases they seem to be partially decomposed, and may give rise to this reddish appearance, but the immediate contact of these with partially altered olivine crystals leads us to attribute it to limonitic discolourations produced by the oxidation of the iron in the olivine, and we are supported in this conclusion by the fact that the iron crystals seem to be in beautiful preservation, and moreover the greyish white decomposition product which so often accompanies the breaking down of titaniferous iron is wholly absent here.

MAGNETITE, (*m.*) *n.* [Lat. *magnes*, *magnetis*, Gr. *Μαγνήτης*, or *Μαγνήδιος*, *i.e.*, Magnesian stone, from Magnesia, Gr. *Μαγνησία*, a country in Thessaly; or according to PLINY, from MAGNES, who is said to have discovered it from the attraction of his shoe nails, and the iron ferrule of his staff to the ground over which he walked]. MAGNETIC IRON ORE. A very few lozenge-shaped and squarish opaque black and rarely semi-translucent reddish forms, which are probably sections of magnetite crystals may reward a careful search, but all doubts as to the occurrence of that mineral seem to be removed with the use of a moderately high magnifying power (300 diameters) with which perfect little octahedra, acicular, oblong, and granular irregular microliths may be seen in the serpentinous strings of green and yellow matter in the olivine, and amidst the green decomposition patches

BIOTITE, *b. n.* [So called after BIOT], occurs in elongated narrow scales, and shorter broad plates, chiefly in the green serpentine and decomposed parts, and at the edges of the white decomposition products. The scales vary in length from .0149—.0055 in.; and in breadth from .0049—.0009 in. and are all markedly striated in a longitudinal direction. In thin sections they are all of a uniform delicate pinkish brown tint, but in thick sections become rich brown. Under a power of 500 diameters their ends seem to be frayed out, but many of them show clean cut edges. A few of the crystals are dichroic, but most of them appear dark, or preserve their ordinary colour, when illuminated, between crossed Nicols, and these are probably cut parallel to their basal planes. Wherever the biotite is found, it may be observed that two or more, often five or six, of the crystals lie near to one another. We have not found any isolated examples.

APATITE, (*ap*) *n.* [From Gr. *ἀπατη*, *deceit*, *ἀπατάν*, to deceive. So called because the older mineralogists were very often deceived by its appearances, mistaking it for aquamarine, chrysolite, etc]. With a power of about 50 diameters there may be seen, in certain of the green patches, a few colourless, rectangular, narrow, but greatly elongated minute crystals, with here and there a small pellucid hexagonal section. In length they measure from .033—.0093 in., and in breadth from .0037—.0024 in. That these are crystals of apatite there cannot be the least shadow of a doubt, for with higher powers and the use of polarised light their true nature may be clearly demonstrated. We have directed attention to the fact that only *some* of the green patches of serpentinoid matter are invaded by these beautiful prisms; we may further state that *most* of the patches of green are devoid of them, nor do they obtain in other parts of the field. They are usually in groups of many crystals, and rarely as isolated forms. With a power of 100 diameters we may note that each rectangular elongated section exhibits transverse dislocations at

EXPLANATION OF PLATE.

FIG. I. $\times 25$.

- O. Olivine, serpentinised, but still comparatively fresh.
- O' Olivine with edges rounded off, supposed by some to be due to a secondary fusion.
- O" Olivine which has undergone considerable alteration. The iron has been oxidised, and the whole crystal form filled with the hydrous result. At the bottom of the plate O" shows a further superinduced fissile structure.
- Ol. Endomorph of olivine within the augite.
- S. Serpentinoid, green alteration product; exhibiting occasionally a rectangular grating-like fibrous texture, as well as a meshwork appearance; probably due to the metamorphosis of enstatite as well as olivine (ROSENBUSCH).
- Au. Crystal of augite, obscurely octagonal.
- W. Whitish crystals and decomposition products, probably forms of massive enstatite and phases of its primary alteration in addition to other pale associated aggregates.
- T. Plates of titaniferous iron. A little below the iron at the bottom of the illustration two minute granules and a small hexagonal section of the same mineral are shown.
- B. Scales and plates of biotite.
- L. Limonitic discolorations.

FIG. II. $\times 20$.

Crystal of augite (a) with endomorphs of olivine (e, e', e"). olivine (e).
 olivine with rounded angles (e'). olivine only partially enveloped (e").

FIG. III. $\times 695$.

Scales and plates of biotite. (a), Elongated scale $\times 69\cdot5$. (b) Short broad plate $\times 69\cdot5$. (c), Frayed out end of a scale $+ 695$.

FIG. IV. $\times 150$.

Crystals of apatite, (a), Elongated rectangular forms arranged in linear increasing series. (p), Short isolated prism. (h, h). Transverse hexagonal sections.

FIG. V.

Magnetite. (o), Square section $\times 150$. (o'), Lzenge-shaped section $\times 150$. (t), triangular section, with rounded angles $\times 150$. (m), Microliths $\times 700$.
 (s), Air or gas cavity $\times 700$.

FIG. VI.

Titaniferous iron. (p). Plate somewhat broken $\times 25$. (h), Hexagonal section $\times 150$. (h'), Hexagonal plate $\times 695$.

intervals, and that many of the crystals which appeared under the lower power to be enormously elongated and tapering, are in reality a longitudinal arrangement of gradually diminishing members. A power of 500 diameters brought to bear upon *most* of the green patches, and especially upon those containing the apatite prisms, is almost starting in its revelations; there may be seen little isolated stellately arranged groups of excessively minute colourless somewhat flattened prisms radiating from centrally situated ones, and at the borders of the green product multitudes of these little crystals project outwards into the green ground from separate centres; similar isolated prisms are scattered about at intervals, and a host of acicular clear glassy particles of various sizes may be detected. That all these structures are apatite crystals is doubtful, yet from analogy and their mode of occurrence it seems plausible at least to regard them as such, for they are of similar shapes, and exhibit the same colour as the larger crystals, and what is more important they obtain in greatest abundance immediately around the larger crystals, the hexagonal sections of which are literally surrounded by them. Between crossed Nicols the longitudinal rectangular sections may be still clearly discerned, but the transverse hexagonal ones become perfectly dark and obscure. The minute prisms we have described are too small to admit of the analysis of polarised light, and even if they could be seen the result would be vitiated by the interposition of the green matrix in which they are situated.

In our illustration, which shows a section of the rock, magnified 25 diameters, a large, irregular crystal of augite, of a pinkish-yellow colour, is shown with an enclosure of olivine. At the right hand side may be seen three well defined crystals of olivine, partially serpentinitised; between these and the augite, a little above the centre of the picture towards the left, a crystal of olivine is shown, with rounded angles. The green colour indicates the serpentinitoid alteration product, and the grey shows the position of the white altered material. At the top of the field, five scales of rich brown biotite are shown, and between the black crystal of titaniferous iron at the top, and the long scale of biotite, a dark brown plate of olivine, which seems to be a pseudomorph of limonite, is depicted. The apatite is not shown; indeed, it can just barely be detected under such a low power. The magnetite, of course, cannot be seen at all with a magnifying power of 25 diameters.

In the first portion of this description, we detailed, briefly, some of the characteristics of other igneous rocks, which are usually classified, with pikrite, as rocks of exceptional mineral constitution. We did so, because it is our desire to point out that this little group of igneous rocks in the character which they possess in common, of foreshadowing serpentine, admits of a thoroughly rational classification. And this is an opportune moment for us to introduce an innovation in the nomenclature of rocks, which if fully carried out by competent mineralogists, would, we believe, be the foundation of a strictly scientific classification. Thus, under the head of *serpentinogenic* rocks we may form two groups, an *igneous* and an *aqueous* (?). These groups may be divided into genera, and the genera into species. Thus, in the igneous group we would have the genus Lherzolite, Dunite, Pikrite, etc., and the genera may be divided into species from the localities in which they are found, the

mode of their occurrence, from some exceptional or predominating constituent, peculiar texture, or other more or less cogent reason, and a generic as well as a specific name thus applied to each and every rock to distinguish it from all other rocks; and in this way a system of petrology might be built up which would vie with those of the biological sciences.

METHODS OF PREPARATION.

It is only within comparatively recent times that the compound microscope was first applied to the investigation of the minute structure of minerals and rocks. Anatomists and chemists were long familiar with the instrument, but the mode of preparing hard sections by mechanical methods for examination under the microscope was not introduced until WITHAM, in 1831, published his researches on the internal structure of fossil plants*. To NICOL, of Edinburgh, however, belongs the honour of having invented that process, and we are told on the authority of SORBY† that NICOL prepared the specimens and wrote the description of his processes for WITHAM's book. BALFOUR‡ also describes the method as that of NICOL. In his researches on the comparative anatomy of the teeth OWEN, and in his study of the dental tissues, NASMYTH employed similar means for obtaining hard thin sections, and CARPENTER§ first applied the method in revealing the minute structure of recent shells.

Up to this period mineralogists were wont to employ the time honoured simple lens in their observations of the intimate structure of minerals and rocks. It is true that in 1838 DUFÉRNAU** used the microscope in his examination of volcanic ashes, but then he did not cut sections of the rocks, nor did he carry his researches any further, and this state of affairs continued until SORBY†† in 1858 communicated the results of his microscopical analyses of minerals and rocks to the Geological Society. This was the commencement of the study of a branch of lithology, which in the short course of twenty-four years, has assumed such vast proportions, that it is fully entitled to rank as the chief department of mineralogical science. The example set by SORBY in this country, and supported later on by DAVID FORBES*‡ was ardently followed by their continental contemporaries, and it is especially due to the indefatigable labours of the German mineralogists that microscopical lithology has assumed its present elaborate form. The German school was founded by F. GIRKEL who published his first paper entitled *Mikroskopische Untersuchung von Gesteinen und Mineralien**§ in 1863, and this, his subsequent work, and HERMANN

* *Observations on Fossil Vegetables*, by H. WITHAM, Edinburgh and London, 1831.

† *Preparation of Transparent Sections of Rocks and Minerals*, by H. C. SORBY, A Paper read before the Sheffield Microscopical Society, March 3rd, 1882. See *The Northern Microscopist*, London, May and June, 1882.

‡ *Class Book of Botany*, by J. H. BALFOUR, Edinburgh, 1870.

§ *Report on the Microscopical Structure of Shells*, Rep. Brit. Assoc. 1848.

** *Annales des Mines*, 3e Série, Tome xii, p. 355.

†† *On the Microscopic Structure of Crystals indicating the origin of Minerals and Rocks*, Q. J. Geol. Soc., London, 1858, Vol. xiv, pp. 453-500.

*‡ *The Microscope in Geology*, *Popular Science Review*, Vol. vi, 1867. pp. 355-368.

*§ *Verhrndhand der k. k. geologischen Reichsanstalt*, Jahrgang 13, s. 8.

VOGELSANG's memoir published in *Poggendorff's Annals** followed shortly after by his *Philosophie der Geologie*† attracted workers from all parts of the world into this field of inquiry. In Germany a long list of illustrious names support those of ZIRKEL and VOGELSANG; amongst these we may more especially mention H. BEHRENS, E. BORICKY, E. COHEN, H. FISCHER, C. W. C. FUCHS, C. W. GÜMBEL, G. A. KENNGOTT, KOSMANN, AVON LASAUBX, H. LASPEYRES, H. MÖHL, G. VOM RATH, G. ROSE, H. ROSENBUSCH, F. SANDBERGER, A. SCHRAUF, A. STELZNER, A. STRENG, G. TSCHERMAK, and C. E. WEISS. In France much good work has been done recently through the contributions of CORDIER, De LAMÉTHÉRIE, DESCLOIZEAUX, DUROCHER, FOUQUÉ, and LÉVY. And lastly, in America and in this country ALLPORT, BONNEY, J. W. DAWSON, A. GEIKIE, HULL, RUTLEY, and others, have added very materially to our knowledge of the microscopical structure of minerals and rocks.

As the methods employed in the study of microscopical lithology depend very largely upon the physical properties of minerals and rocks, we often find it necessary to subject the specimen to a preliminary mode of treatment to enable us to slice and grind it into thin sections, but there are other means at our disposal often of as much interest to the biologist as to the petrologist. Thus, in the examination of the famous Barbadoes earth multitudes of exquisite siliceous tests of Radiolarians and Diatoms may be isolated by the judicious use of chemical reagents, aided by careful levigation. By a similar process in his researches into the London clay SHRUBSOLE brought to light myriads of beautiful Diatoms, encrusted with a coating of iron pyrites; and the same methods applied to volcanic ashes, clays, marls, and especially to glacial deposits, is often productive of a rich harvest of the more fragile forms of animal life, and the delicate remains of plants. In addition to all this the presence of mineral particles of exceptional occurrence or excessively minute forms, which would defy the utmost endeavours of the analytical chemist, yield most readily to this mode of observation, and often furnish evidence of extreme interest in the paragenesis of the structure.

The method of pulverisation, in conjunction with that of levigation, comes opportunely to our aid in the study of the more compact rocks, and we have already noted that the application of the microscope to petrological research was first made use of in this direction by DUFRÉNOY. The residuum obtained by means of levigation, whether of pulverised hard and compact rocks, or of those of a softer and less dense texture, may be examined under the microscope dry or in water, or prepared as permanent objects in Canada balsam. Previous to mounting in the balsam, the powdered rock or washed deposit should be soaked for a few hours in turpentine or benzol in a small corked test tube; a portion removed by means of a pipette on to a thin cover glass, should be gently heated over a spirit or Bunsen flame until it is nearly dry and assumes a sodden appearance, a

* *Ueber die mikroskopische Structur der Schlacken und über die Beziehung der Mikrostruktur zur Genesis der Krystallinischen Gesteine*, Pogg. Ann., xxi, 1864, pp. 101-124.

† *Philosophie der Geologie*, von. H. VOGELSANG Bonn, 1867.

drop of liquid balsam dissolved in benzol* applied to it, and laid aside for a few hours in a suitable tray, protected from dust; another drop of balsam may now be placed on a clean glass slip and gently heated, and the cover glass with the object upon it carefully lowered on to the balsamed slip. If these precautions are taken, and the exact quantity of balsam used, which a very little practice will determine, the preparation will be found to be perfectly mounted with a clear bevelled rim of the medium solidified when dry into a sloping edge.

In a future article we shall detail the special methods of pulverisation and levigation as applied to the requirements of typical deposits and rocks, such as the isolation of siliceous organic forms, and the separation of calcareous tests and mineral particles.

THE METHOD OF PREPARING THIN SECTIONS OF MINERALS AND ROCKS.

Most minerals and rocks when perfectly fresh admit of being cut and ground down into thin sections without any previous mode of treatment, but there are very many which would break into small fragments or crumble to a powder, if we attempted to handle them under such circumstances; as examples we may mention the fibrous varieties of pyroxene, shales and schists, clays and marls, soft chalks, and most weathered rocks.

PRELIMINARY.—All minerals and rocks whose texture does not permit of mechanical treatment should be procured in the form of small chips or fragments, or, where it is possible, in slices ranging from one-half to one-eighth of an inch in thickness. In the case of glacial clays and soft chalks, and all rocks which in their natural state are usually gathered with a large quantity of water in them, they should be gradually dried, but not heated to such an extent as to cause them to crumble away on being touched; immersion for a short period in methylated spirit will render them suitable for the next operation, which consists of soaking them in turpentine for a time varying from a few minutes to several hours, until they are thoroughly saturated. The next process consists in applying a quantity of hardened Canada balsam to them, and may be best accomplished thus:—A quantity of balsam placed in a sand or water bath, or subjected to gentle heat, should be tested from time to time by removing a small drop with a glass rod; as soon as the balsam shows a tendency to become hard on cooling, the turpentine soaked specimens may be placed in it and the heating continued until they are thoroughly impregnated with the hardened balsam; they may then be removed and laid aside until quite cold. A primitive mode of carrying out this process is to place the balsam unhardened on the turpentine soaked material, to lay it aside in a warm place, and to repeat the operation until it becomes hardened, but this is a most unsatisfactory plan, and at best but a slovenly method. A solution of shellac in spirits of wine or of Canada balsam in chloroform or benzol may be used instead of hardened balsam, but neither of these are so uniformly successful in their application. Thus prepared the specimen may be cut into slices.

* The successful mounting of objects in Canada balsam depends very much on the purity and consistency of the medium. Wherever we recommend the use of balsam, we desire it to be understood that hardened balsam, which has been dissolved in pure benzol, and filtered once or twice till it is moderately viscous, should be used.

1ST PROCESS.—*Cutting the slices or procuring chips.*—Where practicable it is always best to secure large fragments of rocks, from three to five inches square, and to chip or slice them afterwards at leisure; but this cannot always be accomplished, and in that case chips should be taken in the field. A sharp blow with the edge of a geological hammer* will with a little practice enable anyone to detach a sufficiently thin and large chip. MR. RUTLEY in his small volume "*On the Study of Rocks*" gives the following directions for obtaining chips from minerals and rocks, which we have found a most useful method:—"As it is desirable to lessen the labour of grinding as much as possible, the first thing to be done is to procure a thin chip or a thin slice of the mineral or rock about to be examined. A square inch is a convenient size for the chip or slice, as such a piece will often undergo considerable diminution before it is reduced to a sufficiently thin state. Chips may be procured by using a small hammer, but frequently a number of flakes have to be struck off before one of suitable size, thinness, and flatness is got. When the specimen is very small, and difficult to hold in the hand while the hammer is used, a satisfactory chip may often be procured by holding the fragment in a suitable position on the edge of a cold chisel either let into a block of wood, or screwed into a vice, but then the operator must take care of his fingers. In the chipping of very hard rocks, it is also advisable to protect the eyes, especially when the hammerer is not well practised in stone breaking. For this purpose a pair of wire gauze spectacles will be found useful. When cleavable minerals are to be dealt with, it is best to avail oneself of the cleavage, but also to note in which direction of cleavage the plate is struck off, and, if it be desirable to make a section in some other plane than that of cleavage, a slitting or sawing process hereafter to be described, is the only way in which such a section can be procured."

The slicing of minerals and rocks may be accomplished either by hand or with the use of a suitable machine. Hand slicing, when applied to substances whose hardness exceeds 5 or 6, is apt to become very tedious; it may be effected by the use of a toothless framed saw of soft iron, charged with fine flour emery and water, or a bow made of bamboo or some other pliant, yet strong material, with a string of soft iron wire and similarly charged may also be used.**

* The form of hammer devised by PROF. A. GEIKIE, and known as the "*Geological Survey*" pattern is very useful for this work. For general purposes however a tolerably heavy hammer with a head of Swede-iron with well tempered steel ends welded on, is recommended by MR. RUTLEY. One end of the hammer head should be square, and the other ought to taper to a wedge with an obliquely decollated extremity. The eye into which the handle is fitted should be at least 1½ in. in length by ½ in. in breadth, and filed away slightly round its under opening to reduce the chance of snapping the shaft. The latter should be made of some tough wood, preferably ash, free from knots or flaws, and thoroughly well seasoned; it should moreover be as thin as it can conveniently be made, and tightened in the eye of the head by means of a small iron wedge inserted into a slit at its upper end. A few of these wedges should be carried in a pocket lined with soft leather (an admirable form of geological bag) to guard against mishaps, and if the handle snaps, which usually happens immediately below the head, a strong pen knife will be found serviceable provided the shaft is long enough; it is well to have the shaft at least 13 inches, and better still to use one 24 inches in length.

** For this method we are indebted to MR. H. HENSOLDT, of Wetzlar.

Numerous slicing and grinding machines have from time to time been constructed, ranging from inexpensive worthless toys to elaborate amateur's lathes. We cannot, however, recommend any of these instruments as at all approaching in excellence of working qualities the cumbersome, yet effective lapidary's bench, the value of which has been determined by the experience of generations of able workmen, whose utmost endeavours have been exerted in the production of a machine to enable them to maintain their stand in the struggle for existence.

The working lapidary provides himself with a strong heavily made table about 3 feet in height, 3 feet 6 inches in length, and 2 feet in breadth. The top of the table is divided into two tray-like compartments, with ledges 6 inches in height; one of these divisions is 2 feet 4 inches by 2 feet, and the other 1 foot 2 inches by two feet in size. The centre of the larger of these compartments is bored by an aperture, through which the axle of a very heavy iron fly-wheel, placed horizontally, is made to pass, and to terminate above the table in a handle secured by a nut, and by means of which the fly-wheel can be set in motion; the lower end of the axle is pointed, and revolves upon a bearing of *lignum vitæ*.^{*} The smaller compartment, also, has a central aperture, through which a spindle carrying a lap or disc 9 inches in diameter is passed; it revolves both above and below between *lignum vitæ* bearings, but the upper bearing may be made of steel, and can be adjusted by means of a nut from above. A leather strap, or hempen thong, is placed around the fly-wheel, and a grooved, enlarged portion of the spindle on a level with the fly-wheel, and both are thus made to revolve by turning the handle of the fly-wheel. Close to the edge of the lap a vertical iron rod, encased in a movable piece of wood, is fixed; the wood is pierced by a number of holes at stated intervals, into which pegs may be placed at will at right angles to the rod and at any height above the lap; these pegs form extemporaneous rests for the hand whilst holding specimens which require to be ground at certain different angles, as in the production of facettes on precious stones, and is called a "*gimp peg*." A can of water or of oil, with a regulating tap for dropping the liquid near to the edge of the slitting disc, or on to any portion of the surface of the lap, may be fixed in a convenient position by means of a bent arm, fastened to the top of the table or to the support which holds the upper bearing of the lap spindle.

The dimensions given above are specially adapted to petrological work. One splitting disc and four laps are also necessary, each one fitted on to its own spindle. The splitting disc is made of a circular thin sheet of soft iron, tinned plate is often used. In slicing the mineral or rock, the edge of the disc should be charged with diamond dust, made into a paste with a little sweet oil; a very small quantity applied to the edge with a brush or the finger, must be worked into the metal with a small glass roller. The fragment to be sliced may either be held in the hand, or fastened by means of red cement or elastic glue, to a block which

^{*}Working lapidaries always use *lignum vitæ* instead of metallic bearings, as the latter are apt to induce a slight springy motion to the lap, which would be fatal to the production of true facettes on gems. Such *lignum vitæ* bearings, if properly used, ought to last for two or three years unimpaired, and then they can be readily renewed.

can be pressed steadily against the rotating disc ; great care must be taken in doing this to keep the edge of the slicer well lubricated with oil-of-brick, or soft soap and water, and in commencing the operation the part of the fragment first operated upon should be deprived of any sharp angles it may happen to have by means of an old iron file or a jeweller's emery file. If these precautions are not taken, the diamond charged edge will inevitably be stripped off.

2ND PROCESS.—The chip or slice of rock procured, must next be ground perfectly flat on one side and then polished ; this may be done either by hand or on the grinding bench. If by hand, four plates should be procured, each about 15 inches square ; two of lead, zinc, or better still of lap metal, one of pewter, and one of plate glass. The chip or slice must be ground perfectly flat on one side, with moderately fine emery on one of the lap metal plates, then with still finer emery on the second lap metal plate, and the process repeated with flour emery on the pewter plate ; it should next be polished with jeweller's rouge, rotten stone or putty powder on the glass plate : between each change the slice should be thoroughly well washed. The grinding and polishing should be conducted by a circular movement of the hand over all parts of the plates, to prevent the possibility of their wearing into hollows. The grinding bench should be furnished with four laps, made of similar materials, and used with the same substances as those noted for the plates ; the motion imparted by the left hand to the handle of the fly-wheel should be from left to right, and the slice or chip held in the right hand should be dragged backwards and moved forwards in a tangential direction, and from the circumference towards the centre of the rotating disc ; this will prevent the irregular wearing of the lap, and accelerate the reduction of the section. The emery powder, which has been thrown off the disc into the tin tray, should be gathered after each grinding process, washed and re-collected for future use ; flour emery which has been treated in this manner five or six times, becomes eminently well suited to the production of a smooth flat surface when used on a piece of plate glass ; it is even preferable to the washed emery used by mirror polishers. It is not absolutely necessary to induce a high polish, all that is required is a perfectly flat and smooth surface free from scratches, and this can be secured with rotten stone* or putty powder even on the pewter lap ; red crocus (jeweller's rouge) is objectionable as a polishing agent, because it adheres so tenaciously to the specimen, and enters minute crevices, from which it is sometimes very difficult to dislodge it. Sometimes, especially with very thin slices or chips, it becomes very tedious to hold the section evenly on the grinding surface under the fingers, and the skin is apt to be worn away ; to overcome this the specimen may be fastened on to a small block of wood (an old cotton reel makes an excellent holder), and its position thus easily maintained. The shellac stick used by working jewellers is a good cement for this purpose ; it is sufficiently tenacious to hold the section firmly, yet brittle enough to admit of its immediate detachment with the point of a knife. Prout's elastic glue or Waller's wax may also be used.

* Rotten-stone should always be procured in solid pieces, the white variety is the best. It is also sold in the form of a powder, but this is prone to contain gritty particles, which would be fatal to the production of a smooth surface free from scratches.

3RD PROCESS.—The smooth or polished surface of the section must be fastened on to a piece of glass, and the other side reduced until the section is thin enough for microscopical examination. Most fresh mineral and rock sections can with care be removed from the slip of glass upon which they are finally ground to other clean slips, but there are many, *e.g.*, soft, friable, or greatly weathered rocks, which will not admit of such transference, and must be dealt with accordingly; of course they may be left upon the slips upon which they are ground, but then, as these are usually disfigured by scratches, it is desirable to adopt some other plan; a remedy may be found in the following process, which is a slight modification of that first employed by PHILLIPS. The smooth surface of the slice must be thoroughly cleansed by a slight soaking in benzol, just sufficient to remove all particles of rotten stone, rouge, or other material, but not so prolonged as to dissolve out the Canada balsam, with which the specimen has been impregnated, and fixed on to a circular piece of extra white thin glass, about one inch in diameter; this in its turn should be fastened on to an ordinary slip or piece of plate glass, and the reduction by grinding then carried on. When sufficiently thin the small circle of glass with the specimen attached to it can be removed on to a good clean slip, fixed there, and covered in the usual way. Fresh minerals and rocks, after having been ground thin enough, should be removed by a gentle heat with the aid of a small scalpel or other knife, into a watch glass or porcelain dish full of benzol, and thoroughly cleansed with a soft brush after a short soaking; a very little practice will enable one to take the section up on to the blade of a knife, drain away the adhering benzol, and mount it in Canada balsam under a thin cover.

To fasten the slice on to the glass, various cements may be used, amongst these we may mention Prout's elastic glue, transparent marine glue, a mixture of equal parts of resin and bees' wax, a mixture of bees' wax, gum dammar and Canada balsam, and best of all, hardened Canada balsam. For the sake of convenience the Canada balsam should be hardened by means of a water bath, or by a gentle heat, until it shows a tendency to become hard on cooling; whilst still warm it may be put up in the form of small pills, by dropping portions upon a cold plate or saucer, and rolling each drop into a pilule, or it may be moulded into the form of a rod or stick. A small portion of the balsam hardened in this way should be melted on an ordinary glass slip (some prefer a slip of plate glass), and the smooth surface of the section pressed upon it with a sliding motion, to the exclusion of bubbles of air; the superfluous balsam thus squeezed out must be scraped away from the slide before it has had time to solidify; if it is not removed it will form a very serious source of annoyance afterwards, by becoming a vehicle for particles of grit and emery powder, which may prove disastrous to the section in its final reduction, and if it is scraped off after it has solidified, such a process is apt to detach the specimen from the glass. It is not necessary to use a clip to hold the section in its place, for, when perfectly cold, the attachment of the specimen will be found to have been perfectly secured. The process of reduction may now be carried on with comparative ease, commencing with fine emery on the second lap metal plate, and finishing with flour emery on the glass disc until it has been ground so thin that

when examined under the microscope, the minute characters of the mineral may be identified, or the individual constituents of the rock are seen to lie side by side, and not one over the other ; it may then be polished, cleared, and mounted. Some specimens require to be cut excessively thin, whilst the value of others depends upon their being cut only moderately thin ; it thus becomes necessary to make constant use of the microscope to determine the exact moment when the section should be removed, and it is often useful to grind down one part of the section more than another ; this is comparatively easy work, for the centre of the section, even when great care is taken and a perfectly flat grinding surface used, is usually thicker than the edges, sometimes disagreeably so. There is only one remedy for this, and that is to reverse the state of affairs ; here a flat surface produces a slightly convex one. All that has to be done, then, is to use a slightly convex grinding surface to obtain an evenly ground section.

4TH PROCESS.—*Mounting the Sections.*—Place one or two drops of Canada balsam on a clean glass slip, and warm it gently over a spirit or Bunsen flame. A few air bubbles may rise to the top, but they are soon dissipated ; remove the section from the benzol, drain it, and lower it on to the balsam gradually ; place a drop of balsam on the top of the section, heat it slightly, and cover it with a thin glass which has been warmed. If the balsam has been carefully baked, the preparation may be cleaned and labelled as soon as it is cold.

In preparing sections of coal, and some of the softer chalks, clays, etc., neither emery nor any other powder should be used, as they become imbedded in the substance of the material or in the hardened balsam which holds the particles together. The slices ought to be selected from specimens free from cracks, and ground perfectly flat on one side on a slab of coarse slate, Welsh hone, or pumice stone, and polished on a fine grained Water-of-Ayr stone, Turkey stone, or Arkansas hone. They may then be fastened on to a glass slip with hardened Canada balsam, or transparent marine glue, and reduced by means of an iron file or corundum stick, finished off on the fine stone, covered with balsam and mounted.

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del. ad. nat.

J.W. Watson, del. et lith.

T. S. SPINAL CORD OF CAT.
Dorsal Region.
X 20

SPINAL CORD OF CAT.

T. S. Dorsal Region.

× 20.

Etymology.—SPINAL, *a.* [Fr. *spinal*, Sp. *espinal*, It. *spinale*, Lat. *spinalis*, from *spina*, the spine.] Belonging to the spine or back-bone of an animal. CORD, *n.* [Fr. *corde*, Pr., It., and Pg. *corda*, Sp. *cuerda*, from Lat. *chorda*, Gr. *Χορδή*, catgut, string, cord.] (*Anatomy*), The *spinal cord*, *spinal marrow*, *medulla spinalis*, or *myelon*, is that portion of the cerebro-spinal nervous system which is contained within the *medullary* or *vertebral canal*.

DESCRIPTION.

Within the vertebral canal the spinal cord extends as a continuation of the medulla oblongata of the brain from the margin of the occipital foramen of the skull towards the caudal region, and in the adult condition may pass through the whole length of the spine, or come to an extremity at any part between the anterior thoracic region and the end of the tail. In man it ceases after reaching the lower portion of the centrum of the first lumbar vertebra, and is thereafter continued in the form of a thread like structure, termed the *central ligament*, or *filium terminale*. In the cat two very marked enlargements obtain in an otherwise slender cord; a *cervical*, which extends from the third cervical to the first dorsal vertebra, and a *lumbar enlargement*, which is situated at the last dorsal vertebra; after this it tapers gradually until it reaches the caudal vertebræ, whence it continues as the *filium terminale*. As in the case of the brain, the spinal cord is closely invested by a vascular layer of connective tissue, called the *pia mater*, and the delicate serous membrane, or *arachnoid*, is here continued from the cephalic region, in the form of a kind of sac, between which and the *pia mater* a fluid, the *cerebro-spinal fluid*, is contained. The dense periosteal membrane, or *dura mater* of the encephalon, is produced into a sort of sheathing encasement, which is considerably larger and longer than the spinal cord itself and is separated from the walls of the vertebral canal by a large quantity of areolar tissue, richly supplied with venous plexuses. The cord itself is held in position by ligaments, which attach it to its dura mater sheath, as well as by an anterior and posterior system of nerve roots, which pass from its surface towards the intervertebral foramina. At the lower extremity of the cord, the roots are very closely crowded together, and, instead of passing directly outwards to the intervertebral foramina, they take a parallel longitudinal downward course, forming lateral bundles known as the *cauda equina*, to pass out of the sacral foramina.

THE MEGASCOPIK CHARACTERS OF THE SPINAL CORD.—A rough dissection, to isolate the cord from its investing membranes, displays two very obvious fissures, which traverse its entire length, situated along

its ventral and dorsal aspects, and respectively termed the *anterior* and *posterior median fissures*. The anterior extends inwards to about one third of the depth of the cord, it increases in size from the cervical region towards the extremity, and is more distinctly marked than the posterior fissure. An involution of the pia mater, richly supplied with blood vessels, passes into the fissure, at the bottom of which a transverse band of white nerve fibres, the *anterior white commissure* may be seen. The posterior fissure is seen more distinctly towards the upper portion of the cord; a delicate septum of vascular connective tissue passes into it, but the pia mater merely dips into it as a sort of furrow; it extends towards the centre of the cord where it ceases at the *posterior grey commissure*. Besides these two median fissures there are two *lateral furrows* on each side of the cord, which are produced along the lines of attachment of the anterior and posterior roots of the spinal nerves. The posterior of these form a superficial depression on each side of the cord along the lines of attachment of the posterior nerve roots, but the anterior lateral furrows do not produce any marked grooves, because the fibres of the anterior nerve roots do not pass in as a compact bundle, as in the posterior roots, but are spread over a varying breadth. It thus happens that the external contour of the spinal cord exhibits itself in the form of a fluted column, with two primary and median anterior and posterior divisions separating it into two symmetrical halves, each half being in its turn divided into three more or less evident columns by the lateral furrows. The posterior surface of the cervical region is moreover marked by two indefinite longitudinal furrows, and a slender tract thus arises, which has been termed the *posterior median column*.

A further dissection of the cord, aided by the use of a simple lens, reveals the existence of a median longitudinal central canal, the *canalis centralis*, the remains of the primitive groove of the embryo. The anterior and posterior median fissures divide it into two lateral halves, which are connected by the comparatively narrow commissures which immediately surround the central canal, and a very definite arrangement of nervous elements can be made out. The ganglionic corpuscles are confined to the so-called *grey substance* which forms the isthmus and spreads out into two lateral masses, each of which sub-divides into an *anterior* and a *posterior horn*, and these are enveloped by the so-called *white substance*.

A transverse section of any part of the cord shows the grey substance in the form of two crescentic masses connected by the posterior or grey commissure; the convexities of the crescents are turned to each other in the antero-posterior median line, and both of them end in anterior and posterior horns. The anterior horn is short and broad, and spreads out towards the attachment of the anterior nerve roots, thus dividing the white substance around it into two indefinite columns; the bottom of the anterior median fissure is, moreover, separated from the posterior grey commissure by a band of white matter, the so-called *anterior or white commissure*. The posterior is usually longer and narrower than the anterior horn, it passes outwards to the posterior lateral fissure; its back part becomes somewhat enlarged and has been termed the *caput cornu posterioris*, whilst the neck-like portion, which places it in continuity with the rest of the grey matter, is called the *cervix cornu*. The crown of the caput cornu

presents a peculiar modified semitransparent appearance, and is known as the *substantia cineria gelatinosa* of ROLANDO ; on the outer aspect of each crescentic mass between the two horns the grey matter sends out a network of processes which enclose portions of the white substance. The white substance forms the largest portion of the bulk of the cord, it surrounds the grey substance and is traversed by the median fissures already noted as well as by numerous trabeculæ of connective tissue which usually penetrate through it in an irregular manner, although in the cervical region a regularly disposed septum obtains which marks out the posterior median column.

REMAK and VALENTIN have noted that the extremity of the cord is entirely constituted of grey matter. Sections of other parts of the cord show that the grey in relation to the white matter obtains in greatest abundance in the lumbar, less in the cervical, and least of all in the dorsal region. An estimate of actual amounts shows a preponderance of white matter in the cervical, and of grey matter in the lumbar region. The forms of the grey horns also varies ; in the cervical region the anterior are large and broad and the posterior narrow, in the dorsal region both are moderately narrow, whilst in the lumbar region both are very broad.

At an early stage in the development of the embryo a linear depression, the *primitive groove*, is formed on the surface of the blastoderm ; on each side of this the epiblast is raised up by the growth of a mesoblastic ridge beneath it, until by the coalescence of the free edges of these two *dorsal laminae* a cerebro-spinal canal is established. The thickening of the epiblastic layer thus enclosed, and its subsequent elaboration into nervous elements gives rise to the brain and spinal cord. In the osseous fishes (*Teleostei*) the involution of the epiblast results in the enclosure of a solid column of cells, which at a later stage of growth only becomes hollowed out in the spinal region to form its so called ventricle. Amongst the frogs, although the central canal of the cord is patent from the beginning, its elements exhibit a marked distinction into an outer layer of dark tegumentary cells, and an inner investment of an evidently nervous character. No such difference can be detected in birds or mammals ; the layer of epiblast becomes greatly thickened laterally, whilst the anterior and posterior parietes remain thin ; the consequence of this is, that a longitudinal slit is formed, and the primary central canal thus produced, divides into an anterior and a posterior portion by a union at the middle of the opposite surfaces. LOCKHART CLARKE* has shown that the lower of these divisions becomes the permanent central canal of the spinal cord, and that the upper one into which a prolongation of connective tissue from the pia mater passes, loses its canalicular character, and ultimately forms the posterior fissure.

THE MICROSCOPIC CHARACTERS OF THE SPINAL CORD.—The minute structure of the spinal cord is ultimately resolvable into three principal forms of tissue,—*epithelium*, *connective tissue*, and *nervous elements*.

The *epithelium* is manifested in the form of a single layer of ciliated cylindrical cells which line the cavity of the central canal, their attached

* *Researches on the Development of the Spinal Cord in Man, Mammalia, and Birds, Phil. Trans., London, 1862, Vol. 1.*

ends are somewhat conical in form, and usually send filamentous processes into the tissues underneath them; they possess large well defined oval nuclei situated at their basal portions, and KLEIN* describes the occurrence of three or more large disc shaped particles in each nucleus, which the nuclei of the subjacent neuroglia possess in common with them, in addition to which he notes a delicate intranuclear reticulum.

The *connective tissue* forms a large portion of the substance of the cord; it forms a complete investment beneath the pia mater, and sends trabeculæ inwards, which divide and ramify until they merge into a peculiar delicate matrix in which the nervous elements occur, and to which the name *neuroglia* has been applied by VIRCHOW. Immediately around the central canal it occurs as an indefinite ring of a homogeneous gelatinous substance devoid of nerve tissue; it passes gradually on the one hand into the grey substance, and presents at certain parts a finely fibrillated appearance, whilst in contiguity with the central canal it is penetrated by the filiform processes of the epithelial layer, and by connective tissue from the median fissures of the cord, the nuclei of the connective tissue cells in this part closely resemble those of the epithelial cells, and the area thus marked out has been termed the *grey central nucleus*, the *gelatinous central substance*, or the *central ependymal thread*. The connective tissue at the tip of the *caput cornu posterioris*, and known as the *substantia cineria gelatinosa* of ROLANDO, simulates the deeper portion of the ependymal tissue in being almost destitute of nerve elements, which only occur in the form of scattered fibres; it differs from the ependymal tissue in being very rich in cells. In the grey matter the connective tissue forms an excessively delicate reticulum which, when examined with a high power, presents a granular, spongy aspect, filling in the interstices between the nerve elements and blood vessels, and occasionally showing numerous oval smooth nuclei imbedded in a thin surrounding of undifferentiated protoplasm.

Many theories have been brought forward to explain its true nature, the most plausible of which seems to regard it as a delicate network of fibrillæ emanating from branched cells possessing nuclei from which the radiating fibrillæ arise as continuations of their intranuclear network. A transverse section through the white matter magnified about 350 diameters, shows a more marked condition of connective tissue than in the grey matter; large branched connective tissue cells, *neuroglia cells*, are seen intervening between the transversely cut nerve fibres, which are found to be imbedded in a sustentacular substance traceable to the connective tissue; every here and there a highly refractive dot indicates the position of an elastic fibril. The internervous substance thus constituted is found to be in direct continuity with the more massively developed trabeculæ of connective tissue which extend as branched networks from the more homogeneous band of obscurely nervous substance which is covered by the pia mater.

The *nervous elements* of the spinal cord consist of cells and fibres. The white substance is composed almost entirely of fibres, it possesses cells only in the immediate neighbourhood of the grey matter. The fibres vary in diameter from 1.69μ to 17μ , the largest are usually situated

* *Atlas of Histology*, London, 1880, p. 101.

superficially, and the smaller ones more deeply, especially those near the inner angle, formed by the anterior and posterior cornua (KÖLLIKER). They are mostly disposed in a longitudinal direction, but are sometimes obliquely and occasionally horizontally arranged; on rare occasions they may be seen to divide, and the finer fibres often exhibit varicosities. Towards the periphery of the cord they are generally arranged in parallel lines; as they approach the grey matter, however, they often interlace. The oblique fibres are chiefly formed of the root bundles which pass outwards from the anterior and posterior grey horns; horizontal fibres occur as fasciculi in the posterior horn, and both kinds are found in the transverse commissures. On passing into the grey substance these fibres mostly become exceedingly fine, and form a delicate network amidst the connective tissue; those, however, which are connected with the nerve roots are arranged in bundles which take definite directions. The *nerve cells* of the grey matter may be roughly divided into two kinds—large branched cells, which vary in size from $\cdot 0634 - \cdot 1269$ mm., and smaller ones, measuring from $8\cdot 466\mu - \cdot 0634$ mm. Towards the apex of the anterior cornu they form several dense clusters of very large *multipolar ganglion cells*, which vary very considerably in shape and size, and are sometimes pigmented with a brown substance; intervening between these are several large nerve fibres. Similar cells occur more sparingly throughout the grey substance of the anterior horn, and are generally of largest size towards its surface. At the base of the posterior cornu also, smaller cells exhibiting all the same characteristics, obtain. The processes of these cells may, according to DEITERS, pass into the trabeculæ of connective tissue of the white substance, or loop themselves around bundles of nerve fibres; DEAN, FREY, and REISSNER, also, state that these cells are occasionally connected by commissural processes, but other observers have failed to detect them, and DEITERS denies their existence. The processes of these cells are divided by DEITERS into two kinds, an *axis cylinder process*, which does not undergo any division, and becoming enclosed in a medullary sheath at some distance from the nerve cells is converted into a white nerve fibre, and one broad and many smaller branching *grey processes*. There are also some very delicate fibrillæ, which spring at right angles to the protoplasmic processes of the cells; these he has termed *secondary axis cylinders*. In the deeper portions of the posterior cornu, there occur examples of smaller nerve cells, of a somewhat fusiform shape; they resemble the ganglionic corpuscles already noted, in the possession of a small axis cylinder process, and a variable number of protoplasmic branches from which secondary axis cylinders proceed in directions at right angles to those branches. Another group of rounded ramifying cells of moderate size are aggregated at the base of the posterior horn, which are devoid of axial cylinder processes; their branches merely ramify through the substance of the grey matter, and enter into the formation of the complex system of fibrillar arrangements therein.

The true physiological significance of all these cells, and their processes is a question which is still unanswered, and the most conflicting opinions are held even amongst those who have devoted special attention to the subject. The *exact* relations of these cells to one another, and to their surrounding elements throughout the whole of the spinal cord up to the

brain, yet remains to be investigated before any definite functions can be assigned to them, and our present state of knowledge in this department leaves us where it left HALL in 1837, with the broad generalisation that *it is probable that the mode of origin of the nerves of sensation is distinct from that of the nerves of motion.*

BLOOD VESSELS.—The spinal cord is very richly supplied with blood vessels; a large delicate capillary meshwork is formed in the white substance from the vessels of the pia mater which enter the cord along with the trabeculae of connective tissue. The grey substance derives a very dense capillary system, especially in the neighbourhood of the ganglion cells from three twigs, two of which lie in the anterior and one in the posterior fissure, and belong to the anterior median spinal artery. The capillaries thence pass to two specially large veins close to the central canal. All the blood vessels are more or less invested with a layer of connective tissue, between which, and the enclosed vessels His has described a *perivascular system*, supposed by some to be lymphatic.

METHODS OF PREPARATION.

It is absolutely necessary where sections are desired, to subject the spinal cord to some hardening process. Any of the six following methods may be employed with success.

(i.) **CHROMIC ACID.**—The cord with its attached pia mater, should be cut into pieces about half-an-inch long, and placed in three times its bulk of a quarter per cent. watery solution of chromic acid; the solution should be changed at the end of eighteen hours, and at the end of three weeks rectified spirit or good methylated spirit substituted; in about two or three weeks it will be ready for cutting into sections. This method was employed in the preparation of the specimens, from which the illustration was taken.

(ii.) **SPIRIT AND CHROMIC ACID.**—Place pieces half-an-inch long in rectified spirit in a cool place for eighteen hours, transfer to a quarter per cent. watery solution of chromic acid for eighteen hours, renew the fluid, and, at the end of six or seven weeks, retransfer to spirit until required.

(iii.) **CHROMIC ACID AND SPIRIT MIXTURE.**—Dissolve one gramme chromic acid in 20 CC. distilled water, and add it slowly to 180 CC. spirit, allow it to become cold before using. Into this place half inch pieces for from two to three weeks, transfer to spirit until required.

(iv.) **SPIRIT AND IODINE MIXTURE, AND AMMONIUM BICHROMATE.**—Place the cord in a long glass tube of rectified or methylated spirit made slightly brownish with tincture of iodine for three or four days, or until the iodine colour has vanished. Cut into pieces about half an inch long and place them in three times their bulk of a two per cent. watery solution of ammonium bichromate for four or five weeks, transfer to spirit until required.

(v.) **POTASSIC BICHROMATE.**—Place half inch pieces in a two per cent. watery solution, each piece should be wrapped in a small quantity of cotton wool, previously wetted with the fluid. A large quantity of the fluid should be used, and should be changed once or twice during the three or four weeks which it takes to harden. Transfer to spirit until required.

(vi.) MÜLLER'S FLUID AND SPIRIT MIXTURE AND AMMONIUM BICHROMATE—For Müller's fluid, dissolve twenty-five grammes potassic bichromate and ten grammes sodium sulphate in 1,000 CC. distilled water, to three parts of this add one part of rectified or methylated spirit, and allow it to get cold. Place large pieces in this for twenty-four hours in a large quantity of the fluid and in a cool place, change the fluid at the end of a week; the cord should now be cut into half inch pieces, and these allowed to harden for three weeks, transferred to a two per cent. solution of potassium bichromate, for two weeks, and then into spirit until required.

The hardened pieces may be imbedded in paraffin, carrot, or frozen in a strong solution of gum, and cut into sections. They may be stained in log-wood, carmine, or an aniline dye, preferably in a one per cent. solution in distilled water of aniline blue-black. For methods of staining and mounting, see this journal, pp. 6, 40.

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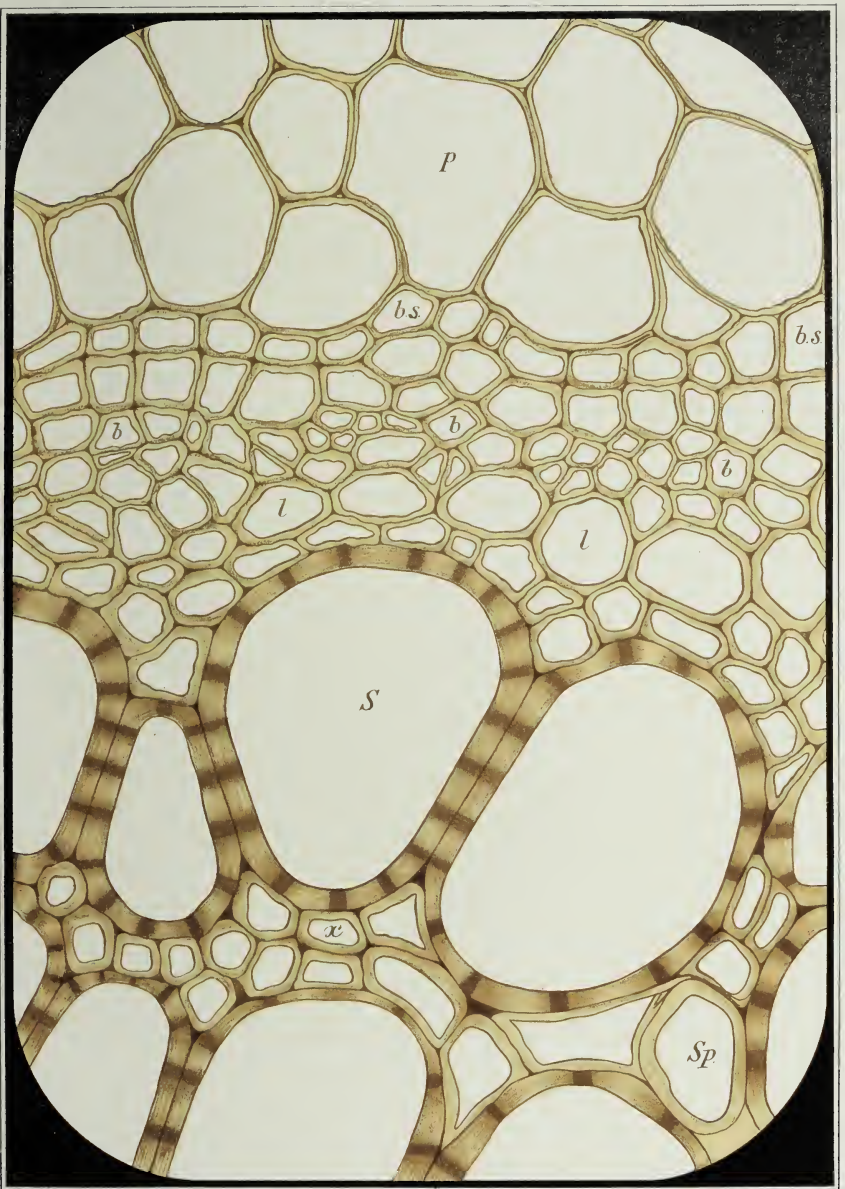
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A. del. ad. nat.

J.W. Watson, del. et hth.

BRACKEN FERN,
T.S. Rachis of Frond.
F.V. BUNDLE, X333.

Watson & Son. Chromo-Lithogrs, Newhall St, Birm.

THE BRACKEN FERN.

(PTERIS AQUILINA.)

T. S. Underground Portion of Rachis.

× 333 diameters.

Etymology.—BRACK'EN, *n.* from BRÅKE, *n.* [L. Ger. *brake*, brush-wood, Dan. *brägne*, *bregne*, fern, W. *brwg*, wood, brake, Arm. *brūk*, *brûg*, heath, heather, Ir. and Gael. *fraoch*, heath, heather, Pr. *bru*, heather]. (*Botany*), A fern of the genus *Pteris*.

FERN, *n.* [A-S. *fearn*, N. H. Ger. *farn*, *farn-kraut*, O. H. Ger. *farn*, *faran*, M. H. Ger. *varn*, D. *vaaren*]. (*Botany*), A class of vascular cryptogamic plants,—the *Filices*.

PTERIS, [Gr. *πτερόν*, a wing]. So called on account of its wing like fronds. AQUILINA, [Lat. *aquilinus*, from *aquila*, an eagle]. Named thus by LINNÆUS* from a fancied resemblance which the markings seen on a transverse section of the rachis bear to the imperial eagle. In Francis's Analysis of British Ferns, p. 55, the following passage occurs:—"In a most rare little book, entitled 'A Dyaloge or Communycation of Two persons devysed or set forth in the Latin Tonge, by the noble and famous clarke Desiderius Erasmus,' intituled, 'The Pilgrimage of Pure Devotion, newly translatyd into Englyshe' (no date, supposed to be 1551,) is the following curious passage:—"Peraventure they ymagyne the symlytude of a tode to be there; evyn as we suppose when we cutte the fearne stalke there to be an eagle." Most of the older English botanists, moreover, notice the popular statement that a section of the rachis exhibits a picture of King Charles's oak.

DESCRIPTION.

The fully developed bracken fern is provided with an irregularly branched creeping underground stem of a dark brown colour, called the *rhizome*; from this numerous filamentous roots are given off in every direction, but chiefly downwards, and attach it most firmly to the ground. One end of the rhizome presents a series of withered stumps, which arise from the nodes of that structure in a manner analogous to the origin of leaves in the higher plants; a progression towards the other end shows that these are in reality the bases of leaves or *fronds* which have flourished and died down during previous seasons; for fully developed fronds are met with in passing to the growing apex of the rhizome, which terminates in a rounded extremity covered with fine hairs. The fronds very often attain a considerable size, and may measure five or six feet in length; they are formed of a stem like central rib termed the *rachis*, which usually extends some distance below the surface of the earth as a simple unbranched rod to join the rhizome at

* *Species Plantarum*, 1533.

one of its nodes; aboveground it develops transverse offshoots which in their turn subdivide into flattened leaflets called *pinnules*. The vernation of the fronds is characteristically *circinate*, as in all ferns, the apex being rolled up towards the base.

A transverse section of the underground part of the rachis examined with a simple lens shows a narrow brown border surrounding a central whitish ground mass, in which a dark brown branched patch medially situated is so universally present in the bracken fern, that it has been handed down in popular tradition as a fac-simile of the royal oak in which King Charles took refuge, and, together with the lighter markings of a yellowish brown which are arranged around it, suggested to the mind of LINNÆUS a resemblance to the imperial eagle sufficiently constant to rank as a specific distinction. The external brown border is formed by the dark epidermal cells, the branched brown portion in the centre consists of an aggregate of coloured and thickened cells termed *sclerenchymatous tissue*, whilst the yellowish-brown patches mark out the areas occupied by the fibro-vascular bundles. A careful dissection of the plant accomplished by means of transverse, longitudinal, and tangential sections as well as by maceration and teasing, shows that these fibro-vascular bundles are not isolated from one another, but anastomose and form a complete connected system which extends throughout the whole structure.

Examined under a power of about 50 diameters, the transverse section shows the epidermis in the form of a brown layer of thick walled cells of somewhat polygonal shapes passing into the more deeply situated sub-epidermal tissue which is constituted by a zone of similar brownish cells, which gradually merge into the thin walled ground parenchyma. The dark brown sclerenchymatous tissue, which takes on the so called characteristic form of King Charles's oak in this situation, is seen to be composed of thick walled cells abruptly marked off from the surrounding parenchyma, and the fibro-vascular bundles whose transverse sections obtain as so many tortuous bands, patches, or dots, are shown to be partially enveloped by brown thick walled cells which become thinner as they shade off into the ground parenchyma. A longitudinal section shows the epidermis to be made up of parenchymatous thick walled brown cells of comparatively regular polygonal shapes; the subepidermal cells are seen to be slightly more elongated, and to pass by shades into the ground parenchyma which is destitute of any brown colouration, is composed of very thin walled regular polygonal cells of various sizes, whose average diameter greatly exceeds that of the epidermal layers; the sclerenchymatous cells are about ten or twelve times as long as they are wide, and usually taper to pointed extremities, but may also present somewhat rectangular terminations and septæ. The brown cells which partially envelop the fibro-vascular bundles are much longer than the parenchyma, into which they shade off, but do not approach either in length or thickness those of the sclerenchyma.

The characters of the component elements of the fibro-vascular bundles can only be satisfactorily determined by the use of moderately high magnifying powers. Our illustration displays a transverse section of one of these bundles magnified 333 diameters. It shows a small portion taken from the inner aspect of the bundle, which is not surrounded by the layer

of thickened brownish cells. The ground parenchyma (*P*) is seen to be composed of large thin-walled polygonal cells; in longitudinal section they are precisely similar in appearance; in the winter months these cells store a large quantity of starch granules in the rhizome; but in the rachis, which flourishes only during the warm periods of the year, very few starch grains can be detected in the protoplasm of the freshly-cut section.

The fibro-vascular bundle forms a closed system, like that of monocotyledonous plants, and all vascular cryptogams, and consists of a central xylem, enclosed in a layer of phloëm. It is limited externally by a band of narrow cells which properly belong to the external tissues, and is termed by some recent authorities the *endodermis*; it is generally known as the *vascular bundle sheath* (*b.s.*), and is composed of narrow somewhat oblong cells, which in longitudinal, resemble the forms they take in transverse sections; they do not contain starch; the cells, moreover, often have their walls, which face the bundle, thickened, and of a dark reddish brown colour. Within the bundle sheath comes a layer of slightly elongated cells, containing starch, and somewhat larger than those of the bundle sheath; to this the name of *inner* or *bast sheath* has been applied.

Next to this layer comes the phloëm of the bundle, which consists of an external usually double zone of small thick walled cells (*b*) the *bast fibres*, and an inner single layer of wide thin walled lattice cells (*l*) termed the *bast vessels*, between which and the xylem (*s*) a band of small thin walled cells, called the *bast parenchyma*, containing starch, obtains. A longitudinal section shows the bast fibres to be greatly elongated, with strongly thickened walls and sieve plate septæ, and the bast parenchyma cells slightly elongated.

The xylem is constituted by a number of enormously enlarged cells and vessels (*S*) with greatly thickened walls, exhibiting bordered pits, which are characteristically elongated into transverse clefts, giving rise to the cell form called *scalariform*, which is so typical of fern structures. Occasionally in the focus of the elliptical transverse section a spiral vessel (*Sp.*) obtains. Between the scalariform vessels, and surrounding the spiral vessels where they occur, lie a number of thin walled parenchymatous cells (*x*) which contain starch in the rhizome in winter, and are collectively termed the *wood parenchyma* of the fibro-vascular system.

METHODS OF PREPARATION.

The freshly cut sections are best preserved as permanent unstained objects in glycerine jelly; see foot-note, p. 4 of this journal. For other methods see this journal, pp. 14-16.

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J. del. ad nat.

J.W. Watson, del. et lith.

V. S. HUMAN LIVER.
Stained Logwood
X 233.3

HUMAN LIVER.

V. S. Stained Logwood.

× 233·3 diameters.

- l. Hepatic cells, v. Interlobular vein, a. Artery,
b. Bile duct, c. Capillary space.
-

Etymology.—HŪ'MAN, *a.* [Lat. *humanus*, from *homo*, man; Fr. *humain*, Pr. *human*, *uman*, Sp. and Pg. *humano*, It. *umano*]. Belonging to man or the human being.

LĪV'ER, *n.* [A-S. *lifer*, Icel. *lifur*, Sw. *lefver*, Dan. and D. *lever*, O. H. Ger. *lebara*, M. H. Ger. *lebere*, N. H. Ger. *leber*.] (*Anatomy*).—The largest gland in the human body, and by far the most bulky of the abdominal viscera; all its functions are not yet fully understood, but it is well known that it secretes the bile, and that it transforms the grape sugar brought to it by means of the portal vein into a substance isomeric with starch ($C_6 H_{10} O_5$) termed *glycogen*, which in its turn is readily converted into grape sugar,—its *glycogenic function* (BERNARD).

The presence of small particles which resemble glycogen in the protoplasm of some of the lowest forms of animal life (*Protozoa*) seems to foreshadow one of the most important functions which the liver performs, although the slightest differentiation of the sarcode cannot be detected; but glycogen has also been demonstrated in most foetal tissues, and as a constituent of amœboid protoplasm in general. The first indications of a glandular structure associated with the alimentary canal and supposed to be analogous to a liver, are to be met with amongst the *Cœlenterata* more particularly the *Anthozoa* and *Hydromedusæ*, where the projecting folds of the walls of the stomach are lined with a pigmented epithelial investment consisting of longitudinally set cells. A somewhat similar arrangement in the form of pad-like rows obtains at the basal portion of the alimentary tract in the nutritive members of the *Siphonophora*, and the large stomach of *Velella* supports a network of so-called "hepatic canals."

On passing to the *Echinodermata* it is true that glandular organs of more complex forms connected with the alimentary system occur, but their relations to that system do not seem to indicate by any means an hepatic significance; such are the *Cuvierian organs* appended to the rectum of many *Holothurie* composed of unbranched cœcal tubes arranged singly or in tufts (*Bohadschia*), racomose glands (*Molpadia*), or

filamentous lobate or tufted canals circularly disposed (*Mülleria*, *Pentacta*); they secrete a sticky substance which is evacuated in the form of fine threads.

In the *Vermes* the mid-gut of *Polyzoa* and *Rotifera* exhibits a layer of pigmented coarsely granular epithelium which is supposed to represent their liver. A further development may be observed in the *Platyhelminthes* where the stomachal cæca of many Planarians and Trematodes are lined by a layer of modified epithelium. The narrowing and lengthening of the lateral appendages of the mid-gut in *Aphrodite* and the secretory function performed by their epithelial cells, is the first well-marked form of independent glandular organ associated with the mid-gut. In *Balanoglossus* the whole of the dorsal surface of the enteric canal succeeding the respiratory portion is covered with glandular appendages in the form of tubes.

Amongst the *Arthropoda* the glandular organs associated with the mid-gut form two groups. In the *Branchiopoda* mostly amongst the *Phyllopoda* the anterior portion of the mid-gut is provided with dilatations which pass into simple or branched tubes, these tubes become somewhat complicated and form a compound tubular gland placed in the cephalic shield (*Limnadia*, *Apus*.) The *Cirripedia* also possess similar organs. In the *Schizopoda* these cæcal tubes are simple, become very long, and pass backwards. The *Entomostraca* present simple diverticula of the enteric walls, but they are interesting inasmuch as they furnish us with an indication of a paired system which is more markedly developed in the double mass of glandular cæca, which fills a large part of the cephalothorax in all *Decapoda*; these masses are undoubtedly of an hepatic nature, and often show this in the remarkable biliary concretions, which may be found in the lobster and crayfish. Another distinct group of hepatic organs open into the posterior part of the mid-gut of many *Arthropoda*; pertaining to this, are the minute diverticula of the mid-gut of *Copepoda*, which become paired, tufted, and glandular, in some of the *Isopoda natatoria*, as in *Bopyrus squillarum*; the *Stomatopoda* moreover are peculiar in the possession of ten lobate glandular tufts placed along the mid-gut. *Epeira* and *Scorpio* and their allies amongst the *Arachnida* possess enteric cæca and tufted glands, which in structure and position accord with the anterior and posterior hepatic organs of the *Crustacea*, but the rest of the *Arthropoda* (*Myriapoda* and *Insecta*) are singular in the possession at the most of but rudimentary hepatic organs.

A further stage may be observed in the *Brachiopoda*; amongst the *Ecardines*, *Crania* exhibits a branched tubular organ which opens into the enlargement of the intestine by several pores; in *Lingula* this system terminates in four efferent ducts which open into the enteron. The *Testicardines* exhibit a still greater development in a pair of large lateral glands, which surround the stomach and are usually connected with it by a variable number of ducts on each side.

The *MOLLUSCA* are almost all provided with well marked hepatic glands which arise primarily as sacculations of the endoderm of the middle portion of the digestive canal and its subsequent development into a more or less complicated organ. In the *Lamellibranchiata*, the liver consists

of several acini connected into large lobes adnate to the alimentary canal, they open into the stomach or succeeding part of the enteric tract. *Chiton*, as typical of the *Placophora*, shows a pair of symmetrical branched tubes communicating with the intestine. In the shelled *Gasteropoda* the liver is the largest gland in the visceral sac, it is composed of a darkly pigmented lobate mass, embracing a greater or less portion of the enteron, and connected therewith by means of a variable number of ducts which open into the mid-gut generally near the region of the stomach-like enlargement. The ducts of several of the lobes unite and widen out in the *Opisthobranchiata* to form a kind of stomachal cæcum, but the forms taken by these ducts are infinite in variety; amongst them may be noticed the numerous hepatic tubes which open into the stomach of *Doris* and *Doridopsis*, the enteric cæca of the *Æolidæ* which send blind prolongations into the dorsal cirri, when those structures are present, and are covered with glandular tissue, and the wide hepatic cæca of *Limapontia* and *Phyllirhoë*. In the *Pteropoda*, *Pneumodermæ* one of the *Gymnosomata*, has a liver composed of branched groups of cæcal tubes, which open into the stomach by wide ducts giving its walls a pitted appearance. In the *Thecosomata* the enteron traverses a simpler form of gland formed of a well-defined compact mass of acini. Lastly, the *Cephalopoda* usually all possess a large and compact gland. *Nautilus* has four distinct lobes, each of which sends a duct to the mid-gut. In the *Dibranchiata* there are only two lobes, in *Sepia* these are quite separate from each other, in *Rossia* they are loosely connected; they are more firmly united in *Argonauta*, whilst in *Loligo* and *Octopus* they are joined together to form a single mass which occupies the greatest portion of the visceral cavity, and surrounds the alimentary canal; their ducts always open into the terminal portion of the cæcum.

Thus far we have observed that the liver of invertebrated animals ranges from a mere modification of the enteric epithelium chiefly distinguishable by means of its altered colour and granular texture, through dilatations of the alimentary canal, their conversion into simple and branched cæca, to the complicated glandular mass of the *Cephalopoda*; but in all these instances we find that the structure, however complex it may become, is always resolvable into a series of cæcal tubes which may branch, but do not anastomose to form a reticular system. The higher forms of the *Tunicata*, if they are to be regarded as a group of the *Invertebrata*, are remarkable for the reticularly disposed hepatic tubes which they present, and which brings that structure into close relationship with the vertebrate liver.*

Amphioxus stands alone amongst vertebrated animals in the possession of a rudimentary liver; it arises as a cæcal tube near the commencement of the alimentary canal, which passes forwards and is lined with a greenish layer of epithelium; that this is its liver is proved from the study of the development of that organ in other *Vertebrata*, where it can be made out that the epithelial layer (*endoderm*) of the rudimentary mid-gut, together with a portion of the subjacent *mesoderm* is formed

* See CHANDELON, *Rech. sur une annexe du tube dig. des Tuniciers*, Bull. Acad. Belg. xxxix.

into a pair of cæcal diverticula lined with a greenish epithelium which is developed into a liver with reticularly anastomosing tubes, and is further provided with a special receptacle for the storage of its excess of biliary secretion—the *gall-bladder*.

DESCRIPTION.

We have briefly noted the most important morphological changes which have been observed in the liver, and the gradual progression which that organ undergoes, amongst the *Invertebrata*, from a simple modification of the endodermal cells of the alimentary tract in the lowest forms, to the compact tubular gland of the more highly organised groups. In passing to the *Vertebrata*, a sharp line of demarcation was supposed to exist, and the gland was said to completely alter in character and belong to an entirely different structural type; the present state of our knowledge, however, makes it obvious that such is not the case, and we are further warranted in assuming that the liver, in its most highly developed condition, is but a greatly metamorphosed compound tubular gland; and thus, instead of being isolated amongst the organs of the body, partakes of a character which places it in close relationship with all other glandular structures. We have already alluded to the reticulated structure which obtains amongst the higher Ascidians, and we have pointed out the simple tubular nature of the liver in *Amphioxus*, with its lining of greenish cells, which links it to the rudimentary liver of the *Craniota*; but whereas the liver of *Amphioxus* is a single diverticulum, that of the other vertebrates is at first paired, or, at all events, very early becomes paired (BALFOUR). In its future development REMAK, BALFOUR, and others are agreed that the hepatic cells are derived from the hypoblast, and that the connective tissue and blood-vessels owe their origin to ingrowths of the mesoblast. If this be the case, and the ultimate terminations of the bile duct find expression in the minute spaces which exist between the hepatic cells, then its compound tubular nature may be taken as fairly established. SCHENK,* however, maintains that the rudimentary liver of vertebrates is formed from a single mass at the lower surface of the duodenum, and that the hypoblastic cells merely give rise to the epithelial lining of the bile ducts and the gall-bladder.

THE MEGASCOPIC CHARACTERS OF THE LIVER.—The liver is invested in a *serous coat*, which, however, does not take any part in its intimate structure; it is also covered by a *fibrous coat* of connective tissue, which is in direct continuity with the delicate interlobular areolar tissue. In those parts of the liver which are closely covered by the serous coat it is less evident than where that coat is absent, as at the posterior border; and at its transverse fissure it becomes greatly thickened, and passes into the substance of the liver as a primary sheath around the portal vein, hepatic artery, and bile duct which enter thereat, and is known as the *capsule of GLISSON*; this layer of tissue becomes finer and finer as the vessels which it ensheaths and accompanies become smaller.

If a portion of fresh liver be examined with a simple lens, what at first presented a coarsely granular appearance is seen to be composed of

* *Lehrbuch d. Vergleich. Embryologie d. Wirbelthiere*, Wien, 1874.

a finely granulated texture arranged in the form of polyhedral masses ; these *hepatic lobules*, as they are termed, are not so well marked in the human subject as in some of the lower mammals, because the areas are produced by the interposition of connective tissue which is continuous with the outer fibrous coat and the capsule of GLISSON, and is but scanty in man, whilst in the pig and polar bear it is very markedly developed. The lobules average in diameter about 9 mm., but they vary very much in size, some being fully 12 mm., whilst others only measure 1.1 mm. in diameter. In the adult human being the lobules cannot be seen so distinctly as in the infant and in some of the lower animals, both on account of the small amount of interlobular connective tissue, and because of the colour of the cellular elements ; still, even with the naked eye, the liver presents a mottled appearance, and a closer inspection shows each lobule to be composed of two differently coloured parts, one darker than the other. This led the older anatomists to suppose that there were two substances in each lobule ; it is now understood that these differences are entirely due to the state of circulation of the blood within the organ ; thus, if an animal be bled to death and the blood vessels of the liver thoroughly washed out with an injection of normal saline solution, the whole organ would present a uniformly pale yellowish colour ; after death the hepatic veins are usually congested and the arteries empty, it then happens that the centre of each lobule is dark and its margin pale, this was termed by KIERNAN *passive congestion*. In diseases of the heart the circulation of the blood through the liver is so modified that what is known as *active congestion* of its vascular system supervenes ; the blood becomes clotted in the capillaries of the hepatic and portal veins in such a manner as to darken the whole of each lobule, leaving pale intermediate spaces here and there. Sometimes in children the margins of the lobules are found dark whilst their centres remain pale, this condition is due to a congestion of the portal system. All these phenomena may be readily explained by the disposition of the blood-vascular system, which will be fully described in a future article.

THE MICROSCOPIC CHARACTERS OF THE LIVER.—Examined with a power of about 50 diameters a stained vertical section of the human liver shows its lobular character very clearly ; each lobule is seen to be composed of numerous cells arranged in elongated irregular groups which extend radially from around a central space, the radii being connected at transverse intervals, and the whole presenting a retiform aspect ; towards the centre of the lobule these rows of cells are tolerably regular, but they lose this character as they approach the periphery ; the cells are moreover placed in single rows being doubled only occasionally. The interspaces between the lobules may also be seen to consist of vessels variously cut, and of other tissue. A power of about 250 diameters will be found sufficient to resolve all these elements satisfactorily ; the central space is seen to be the transverse section of a blood-vessel (*intralobular vein*), the cells are clearly defined, and the interlobular elements are shown to be composed of connective tissue, with blood-vessels and bile-ducts cut in different ways. In a few instances, some of these vessels are cut transversely, and from such a portion the most information can be gained respecting the structure of the

liver in the examination of a stained section. Our illustration portrays a section of this kind; the large space in the drawing (*v*) shows the relation of the *interlobular vein*, a part of the portal system, to the *hepatic cells* (*l*), the *bile duct*, lined with columnar epithelium, shown cut in two places (*b*), the *hepatic artery* (*a*), and the *capillary spaces* (*c*); all these structures, excepting the hepatic cells, are seen to be surrounded by a connective tissue.

THE HEPATIC CELLS fill the interspaces between the capillaries of the blood vessels, and are supported in position by a delicate sustentacular tissue. In a simply stained section they are seen to be distinct from one another and of polyhedral shapes; as yet, the highest power of the microscope in conjunction with all the known methods of manipulation, has failed to demonstrate any cellular envelope, it is therefore stated that the cells consist of masses of protoplasm without any cell wall. They vary in diameter from $11.3 - 28.2\mu$, and average from $18 - 22.6\mu$. Each cell usually contains a single, more rarely two nuclei with nucleoli, measuring from $5.6 - 7.4\mu$ (FREY); the surrounding protoplasm is tolerably firm, and contains numerous fine particles, giving it a granular appearance, which is attributed by recent workers to a delicate intracellular reticular structure. In an unstained fresh section the cells are seen to be of a pale brownish-yellow colour; this is largely due to the biliary pigment disseminated through their protoplasm; fatty globules may also be detected and most clearly shown by the action of dilute osmic acid which blackens them; sometimes a large quantity of fat may occur in the cells and denotes that the animal lived on a very rich diet; for this *fatty infiltration* may be induced by the administration of fatty foods, and is found in all young sucking animals. Where however the protoplasm of the cells is transformed into fat it results in a malignant disease known as *fatty degeneration of the liver*. If the cells are isolated from a newly killed animal and examined with a power of about 500 diameters on a warm stage in serous fluid or normal saline solution, they may be seen to be devoid of a cell-wall, and to exhibit slow amœboid movements (LEUCKART, SCHENK*).

THE CONNECTIVE TISSUE extends over the whole surface of the liver in the form of a thin fibrous coat which becomes thicker at the posterior border, and at the *porta hepatis*; it forms a sheath, the *capsule of GLISSON* which accompanies the portal vein, hepatic artery, and bile-duct to their finer ramifications.

The fibrous superficial coat and the internal ramifications of the capsule of GLISSON are in direct continuity with the interlobular connective tissue, which we have pointed out occurs but sparsely in the normal human subject; when it becomes hypertrophied it constitutes the disease known as *cirrhosis*. In addition to this a very delicate sustentacular system branches off from the interlobular connective tissue; it may be demonstrated by brushing away the hepatic cells from sections which have been cut from carefully hardened pieces, or by staining sections of the fresh tissue with nitrate of silver, and brushing the hepatic cells off. If these precautions are taken, a very delicate reticulated double

* *Centralblatt f. d. Med. Wiss.*, 1869, p. 865.

membrane, with occasional small nuclei, indicating the position of connective tissue corpuscles, will be revealed, and be seen to be distinct from the network of contiguous capillary vessels, and to form a kind of lining membrane for the hepatic cells.

METHODS OF PREPARATION.

The hepatic cells, blood-vessels and lymphatics, bile-ducts, connective tissue, and nervous elements of the liver are so intricately interwoven, that an insight into their mutual relations can only be arrived at by the careful examination of sections successfully treated in a variety of ways. The characters of the hepatic cells may be observed by brushing them off sections made with a VALENTIN'S knife from the liver of a newly killed animal; they may be mounted in glycerine, or stained with osmic acid and mounted in Farrant's solution. In the preparation of stained sections it is advisable to harden the liver, and to cut it by means of the freezing microtome.

(i.) CHROMIC ACID AND SPIRIT MIXTURE.—(See p. 70.)—Place perfectly fresh unwashed pieces of the liver, each about half-an-inch square, in a large quantity of this solution for about twelve hours; at the end of that time a dense precipitate will have been formed by the blood and lymph which exudes from the tissue. Change the fluid, and renew it from time to time as it becomes turbid. At the end of two or three weeks they may be transferred to methylated or rectified spirit until required.

(ii.) MÜLLER'S FLUID.—(See p. 71.)—Pieces about an inch square should be placed in this fluid for about eighteen hours, the solution renewed, and changed occasionally during the five or six weeks which it takes to harden the tissue; after this they may be kept in spirit.

(iii.) POTASSIC BICHROMATE SOLUTION.—A one per cent. watery solution should be used; place half-inch pieces in this, renewing the fluid at the end of eighteen hours, for two weeks; continue the hardening for another fortnight in rectified spirit. A two per cent. solution of potassic bichromate may be used; in that case it should act on the tissues for about five weeks, being occasionally renewed during that time, and finally kept in spirit until required.

STAINING IN LOGWOOD.—The best solution of logwood for staining animal tissues is that used by N. KLEINENBERG, and prepared thus:—

- a. Make a saturated solution of crystallised calcic chloride in 70 per cent. alcohol, and add alum to saturation; filter.
- β. Make a saturated solution of alum in 70 per cent. alcohol.
- γ. Add one part of α to eight of β.
- δ. Make a barely alkaline saturated solution of hæmatoxylin in distilled water.

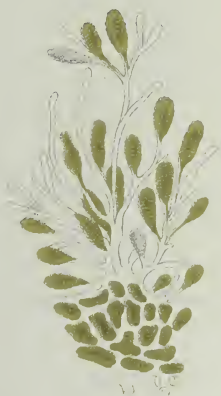
To stain the sections, place them in a small bottle or watch-glass containing a mixture of one ounce of γ and ten or twelve drops of δ, until they are sufficiently coloured, then wash in plain water, and mount in glycerine, glycerine jelly or Farrant's solution. For mounting in Canada

balsam, or dammar solution, the sections should be overstained and the excess of colour removed by steeping them in spirit, when they may be removed to oil of cloves, and mounted in the usual way (See pp. 6, 15).

An excellent logwood stain is prepared by W. MARTINDALE, 10, New Cavendish Street, Portland Place, London, W. Three drops of this dye added to an ounce of distilled water, should be allowed to act upon the sections for about quarter of an hour, or until they are well stained; diffuse colouring may be removed by the use of a very dilute solution of acetic acid. The slices may then be transferred to methylated or rectified spirit for a few minutes, cleared in oil of cloves, and mounted in Canada balsam or dammar solution.



I



II



III

del. ad. nat.

J.W. Watson, del. et lith.

FUCUS VESICULOSUS.
 I. T. S. Thallus. II. Antheridia. III. Oogonia.
 × 154

FUCUS VESICULOSUS.

T. S. of Thallus.

× 154 diameters.

Etymology.—FŪ'CUS, *n.*; *pl.* FŪ'ÇĪ. [Lat. *Fucus*, rock-lichen, orchil, used as a red dye and as a rouge for the cheeks, red or purple colour, disguise, deceit]. (*Botany*), A group of brown sea-weeds, belonging to the order *Melanophyceæ*.

THĀL'LUS, *n.* [Gr. θαλλός, a young shoot or branch, a frond.] (*Botany*), * "In the plants of lowest organisation, Algæ, Fungi, and Lichens, the contrast which is so manifest in those more highly developed between an axis (stem and root) and the lateral organs (leaves), is altogether wanting. With reference to this point, the vegetable kingdom is therefore divided primarily into plants without an axis or *Thallophytes*, and plants with an axis or *Cormophytes*, the term *thallus* being applied to an undifferentiated foliar structure" (THOMÉ).

CON-ÇĒP' TA-CLE (sĕp' ta-kl), *n.* [Lat. *conceptaculum*, from *concupere*, to receive, from *con* and *capere*, to seize or take]. A receptacle, a receiver, that in which anything is contained.

DESCRIPTION.

The *Fucaceæ*, according to THURET, comprise a few genera of the larger sea-weeds of a brownish-green colour; they are often of considerable size, and their tissues possess a somewhat cartilaginous consistency. *Fucus vesiculosus*, the well-known bladder-wrack, occurs largely on the English coast, and may be taken as a type in the study of this group of plants; together with the other marine Algæ, it has long been used by farmers in the vicinity of the sea shore as food for cattle and as a manure; for this purpose it is collected at the end of winter when the fertilisation is over and the young shoots have ceased to sprout. Many of the *Fucaceæ* are used as articles of diet by the poorer classes, both of this and other nations; and the delicate mucilaginous consistency of some tropical species (*F. cartilagenosus*, etc.), is utilised by the Chinese in the preparation of a nutritious jelly-like alimentary substance resembling isinglass. The ashes of *Fucus* were long employed in form of a crude medicine with antiscorbutic and antiscrofulous properties due to the iodine which they contain, and which COURTOIS and GAY-LUSSAC first separated. Soda also was largely obtained from these plants. Most of the *Fucaceæ*

* *Text-Book of Structural and Physiological Botany*, translated and edited by BENNETT, London, 1882, p. 69.

grow on the sea coast between tide marks, or in comparatively shallow water extending down to the Laminarian zone; they are attached to stones or other foreign objects by means of branched root-like discs, although some (*Sargassum bacciferum*, etc.), are well-known to flourish at the surface of the open sea.

THE MEGASCOPIIC CHARACTERS OF FUCUS.—*Fucus vesiculosus*, and its British allies, usually possesses large greenish-brown thallomes, fixed to submarine objects by a branching root-like extremity, which has a tendency to flatten out into a disc-shaped attachment; to this portion the name of *rhizoid* has been applied. No marked differentiation into stem, branches, foliar and reproductive organs can be said to exist, although each and every one of these organs obtain. Thus the rhizoid passes insensibly into an erect stem-like portion, the *thallus*, which branching dichotomously, is further developed into forked-like foliar expansions (*F. vesiculosus*) or sympodial members (*F. platycarpus*); all their ramifications, however, lie primarily in one plane. Every here and there an expansion of the tissue forms a bladder-like structure, and at the seasons of fructification tubercular reproductive organs are developed on various parts of the system, more generally at the ends of the longer forked branches or on special lateral growths of peculiar form. The rhizoids, thallus, and phylloid expansions if cut through are found to be solid throughout; they are of a dull whitish colour internally bounded by a rim of greenish brown, and of a firm, elastic, and somewhat gelatinous consistency; if soaked in fresh water the solid tissue swells up and becomes quite mucilaginous. A section through one of the air-bladders shows a somewhat similar disposition of the tissues, the external periphery is bounded by a layer of coloured cortical cells, which pass into a deeper whitish tissue; internally this passes into a very loose network of hairs which extend toward the central cavity. A section through a fertile tubercle reveals the same primary arrangement of tissues in as far as an outer cortex of coloured cells passes into a whitish firm layer; this in its turn merges into a very gelatinous tissue, which fills the whole of the central portion of the tubercle; in addition to this, numerous small yellowish spots may be seen at the margins of the tubercle; a closer examination of these *conceptacles*, as they are termed, shows them to be minute chambers communicating externally by means of centrally placed orifices, and filled with the reproductive elements.

THE MICROSCOPIC CHARACTERS OF FUCUS.—A power of about 150 diameters is admirably adapted to the study of the tissues of Fucus. A transverse section of the thallus, rhizoid, or phyllome shows that the whole structure consists of parenchymatous tissue, but of a peculiarly unique nature. The outer boundary layer is composed of cells of a somewhat columnar form; the external portions of their cell-walls become thickened and unite to form a cuticular investment; their protoplasmic contents are coarsely granular, the granulations being evidently due to the disposition of green chlorophyll particles, and to what seems to be an intracellular reticulum. The green of the chlorophyll is obscured by the presence of a brownish pigment, which is diffused throughout these cells and those of the subjacent three or four layers. The partial action of alcohol very often removes the brownish colour, and leaves the chlorophyll easily recognis-

able and decidedly green. MILLARDET* in his experiments in this direction noted that cold fresh water extracts a buff-coloured pigment from these plants; he pulverised quickly dried specimens of *Fucus*, from which he obtained an olive-green extract by means of alcohol; this, when mixed with twice its volume of benzine, shaken up and allowed to settle, produced an upper green layer of benzine containing *chlorophyll*, and a lower brownish layer due to the presence of *phycoxanthine*; thin sections of the thallus subjected to the action of the alcohol also revealed a reddish-brown substance, which in fresh cells adheres to the chlorophyll grains; it can be extracted by pulverising quickly dried specimens and soaking the powder in cold fresh water. To this pigment MILLARDET has applied the name *phycophæine*. The cells immediately below the *epidermal* single layer of columnar cells, are like those cells of a brownish olive-green colour, which is due to precisely similar causes; this *sub-epidermal* zone, as we shall term it, is constituted by three or four rows of somewhat columnar cells, those in immediate contiguity with the epidermis being more columniform, whilst the deeper layers exhibit more or less cubical forms. It may be observed that all these subepidermal cells are separated from one another by what seems to be an intercellular substance, and that these appearances are more marked towards the deeper layers; here, too, each brownish mass of protoplasm is surrounded by a distinct hyaline cell-wall. Longitudinal sections show that the cells of both the epidermis and subepidermis are strictly parenchymatous, in that they are of tolerably uniform dimensions in all three directions.

The central portion of the thallus is solid throughout, and is composed of a tissue which is extremely interesting from a morphological point of view; transverse and longitudinal sections enable us to make out an irregular reticulated disposition of elongated cells apparently arranged without any definite order; but an examination of numerous sections both of *Fucus* and especially its ally *Laminaria* shows an *intermediate zone* situated between the subepidermis and central tissue, in which the cellular elements are more or less circularly disposed; towards the centre the cells are chiefly placed in longitudinal series parallel with the growing axis of the thallus. The cells of the intermediate zone and central tissue then, agree with each other in every essential detail except a slight difference in their disposition; longitudinal or transverse sections exhibit them cut in every conceivable direction. Fresh sections examined in normal saline solution, or in diluted glycerine, display the cells filled with a very light yellowish-brown granular protoplasm surrounded by a hyaline highly refractive cell wall of definite contour imbedded in what seems to be a homogeneous matrix. The whole structure reminds us most forcibly of cartilaginous tissue, in the possession of a periplast of a two-fold nature. If we reason analogically we are entitled to regard the hyaline capsular cell-wall as a secretion of the enclosed protoplasm, that such is probably the case is shown by the fact that in sections which have been steeped in spirit, a shrinkage of the protoplasm takes place without laceration, leaving a clear air space between it and the cell-wall. The intercellular substance which forms the apparently homogeneous matrix is evidently constituted by a confluence of the outer portions of neighbouring cell-

* *Comptes Rendus*, Paris, Fev. 22, 1869.

walls, and has resulted from a metabolism of cellulose ; that this is the case, and that a colloid transformation has taken place may be tested by the action of a $\frac{3}{4}$ per cent. solution of sulphuric acid upon the fresh tissue reacted upon with a solution of iodine ; under the microscope the cellulose capsule as well as the modified matrix are seen to become blue. Placed in fresh water, the matrix imbibes it to such an extent that it becomes quite distended and mucilaginous in appearance, whilst the capsular cell-wall remains intact. A confirmatory test may be obtained in the result induced by drying the tissue, the matrix shrivels up and becomes horny in its consistency ; this property is taken advantage of by fishermen and others, who use the thallus of *Laminaria* for knife handles, etc. ; Surgeon's bougies are also sometimes manufactured from the thallus of *Fucaceæ* ; the adaptability of the tissue to such purposes lies in the fact that the cornified substance has a tendency to swell slightly in water and thus completely fills the fissure or wound into which it is introduced. Although this mucilaginous change of the extra cellular portion of the tissue is most marked in the intermediate zone and central portion of the thallus, it is nevertheless present in every part of the structure ; the sub-epidermal layers show it clearly, and even in the epidermis the apposition of contiguous cell-walls is rendered indistinct through this change having taken place along the lines of separation.

If a vertical section be made through the tubercular reproductive portion of the plant, the whole of the interior of that expansion will be seen to be highly gelatinous, and composed of a net-like tissue of elongated parenchymatous cells with capsular cell-walls, and an inter cellular colloid matrix ; the palisade parenchyma of the epidermis displays numerous involutions—the conceptacles ; the epidermis and sub-epidermis grow up around each space thus constituted, and leave but a minute central aperture at each summit. The cells lining the cavity thus enclosed become peculiarly modified to fulfil the reproductive function : at intervals papilloid growths of the tissue take place, and from the sides of these, as well as from the other superficial cells, numerous unbranched articulated hairs of unknown function are developed ; in *Fucus vesiculosus* these trichomes are comparatively short, and are confined within the conceptacle ; in *Fucus platycarpus*, they are longer and project from the central orifice at the summit of each conceptacle. Both male and female elements occur in the same conceptacle in *Fucus platycarpus*, whilst *Fucus vesiculosus* and most of the other British species are diœcious. The male organs, *antheridia*, arise as lateral ramifications from special short filaments, which cannot, however, be distinguished at first from the other hairs. Each antheridium consists of a thin-walled oval cell, the protoplasm of which splits up finally into numerous rounded particles ; in the future course of development, these particles, termed *spermatozoids*, escape from the cell-wall within which they are generated, and present the appearance of minute ovoid masses of naked protoplasm of a firm hyaline nature, each furnished with two motile cilia and an internal reddish spot. The *oogonium*, or female element, occurs in the diœcious *Fucaceæ* in the conceptacles of separate plants from those which contain the male element. The superficial tissue of the conceptacle produces, as in the male, nume-

rous unbranched articulated trichomes surrounding special large cells, which arise as papillose enlargements of the parietal cells of the conceptacle. The papilla thus produced becomes separated from the originating cell by the growth of a septum, and the part thus divided off elongates and forms a second septum, which partitions it off into a lower columniform cell, the *pedicel cell*, and an upper one, which subsequently becomes greatly enlarged, spherical, and fills with a dark protoplasm of a deep orange colour to produce the oogonium. The protoplasm of the oogonium divides into *eight* parts in the *Fucaceæ*; when mature the *oospheres* thus formed are expelled from the oogonium, through the aperture of the conceptacle, and are surrounded by a delicate membranous sac. When the tide has receded, the fertile branches of the plants are exposed to the moist atmosphere; it is then that the reproductive elements are discharged. The mature antheridia at similar times and under analogous conditions make their way out of the male conceptacles, and they, as well as the oospheres, remain attached to their respective plants by means of a slimy exudation which accompanies them, and which is doubtless derived from the altered mucilaginous substance which is so largely generated in the fertile branches. The return of the tide effects the contact of the male and female elements; the spermatozooids collect around the oospheres, and when their numbers are sufficiently great they often impart a rotatory movement to the comparatively gigantic cell, which sometimes lasts for half-an-hour. That the spermatozooids become incorporated with the protoplasm of the oosphere in this process of fertilisation has not yet been decided; but, reasoning from analogy, it is most probable that, as in *Vaucheria* and *Edogonium*, such is the case (Pringsheim*). The fertilised oosphere or *oospore*, as it is now termed, secretes a cell-wall, fixes itself, and commences to germinate and to develop into the adult form. The whole cycle of events in the growth and development of the *Fucaceæ* has not yet been fully investigated.

METHODS OF PREPARATION.

All parts of the plant, with the exception of the fertile expansions, may be cut into sections without any previous method of treatment; they may be preserved unstained in glycerine or glycerine jelly. For the study of the antheridia and oogonia, a slice taken from a fresh fertile branch should be gently teased with needles in normal saline solution, covered, and examined; for permanent preparations, however, it is desirable to obtain very thin sections, and it then becomes necessary to harden the tissues in diluted alcohol for a week before they are sliced.

The sections should be mounted in glycerine or glycerine jelly; in doing this it should be remembered that they ought not to be soaked in water previous to mounting, as the mucilaginous tissue is liable to swell up, and may in many cases become so distorted as to render the preparation worthless.

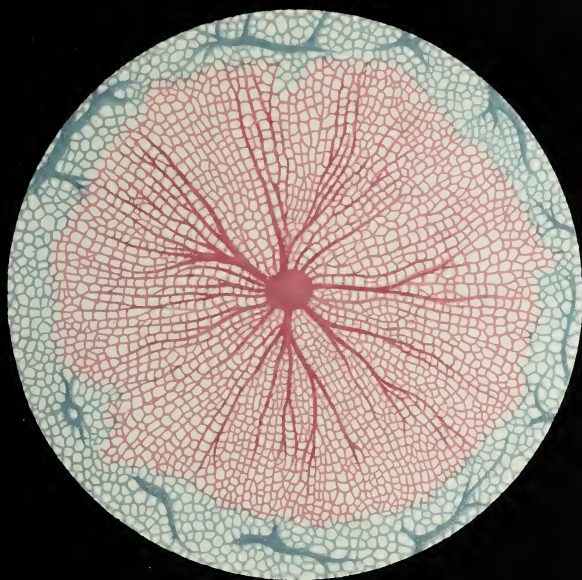
When glycerine is used as the preservative medium, it should be diluted with distilled water to suit the requirements of each case; this is a most important item in the manipulation of some of the very delicate forms of plant life, such as the lower *Algae*. In sealing the object

* *Morphologie der Edogonien*, Jahrb. für wiss. Bot. Vol. I.

pure gold size should be used ; the slide may be held by means of a clip under a cold water tap and the superfluous glycerine thus washed away, it should then be carefully wiped, and a coat of gold size applied to the edges of the cover glass ; the first coat should be allowed to dry thoroughly, and a second, and even a third coat painted on before it is finished off with white zinc cement. A little litharge mixed with the gold size forms a most tenacious cement, and one that resists the penetration of the glycerine remarkably well.

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J. del. ad. nat.

J.W. Watson, del. et lith.

CAT'S LIVER.

Hepatic Vein, Red. Portal Vein, Blue.

× 50.

Watson & Son, Chromo-Lithog's, Newhall St., Birm.

LIVER OF CAT.

V. S. Injected.

Hepatic Vein, Red ; Portal Vein, Blue.

× 50 diameters.

Etymology.—Cāt, *n.* [A-S. *cat*, D. and Dan. *kat*, Sw. *katt*, Icel. *köttir*, L. Ger. *katte*, H. Ger. *katze*, *kater*, O. Fr. and Pr. *cat*, N. Fr. *chat*, Catalan *gat*, Sp. and Pg. *gato*, It. *gatto*, Ir. *cat*, W. *câth*, Corn. *kath*, Armor. *kaz*, *kâch*, Late Lat. *catus*, Bisc. *catua*, N. Gr. γάτα, γάτος, Russ. and Pol. *kot*, Turk. *keci*, Ar. *qitt*]. (*Zoology*). A species of carnivorous animal belonging to the genus *Felis*. *Felis domestica*, the domestic cat, is supposed to be derived from the wild cat (*Felis catus*).

LIVER, see p. 79, for etymology, etc.

DESCRIPTION.

In the accompanying plate, a single lobule of the liver of the cat has been depicted, with the view of showing the relations of the hepatic venous and portal blood-vascular system therein. The hepatic vein has been injected with a red and the portal with a blue mass, by a method to be afterwards described. In the centre of the lobule, which has been specially chosen because it happens to have been symmetrically cut and well injected, the transverse section of the hepatic *intralobular* vein is shown, from which a capillary network is seen to radiate, and to join a system of other *interlobular* capillaries which terminate in variously cut twigs of the portal vein at the periphery of the lobule. The clear spaces left by the capillary meshwork indicate the position of the hepatic cells, and the picture is thus a counter part of what has already been considered at page 83, etc.

THE BLOOD-VASCULAR SYSTEM of the liver is peculiar in that it is derived from two distinct sources,—from the *hepatic artery* and the *portal vein*. The hepatic artery is a branch of the *cœliac axis* and is small when compared with the large organ to which it is distributed ; the portal vein on the other hand is a large vessel formed by the union of the *gastro-splenic*, *pancreatic*, *intestinal*, and *omental veins* ; it lies in company with the hepatic artery and bile-duct in the fold of the gastro-hepatic omentum above the foramen of WINSLOW and thus reaches the transverse fissure of the liver to enter into and ramify through its substance ; at that fissure the hepatic artery lies to the left hand side, the bile-duct to the right, and the portal vein behind them. Numerous lymphatics and nerves accompany them, and they are invested by the sheath of connective tissue known as GLISSON'S capsule. The blood is

conveyed away from the liver by the *hepatic veins* which take an entirely different course from the other vessels; they pass out of the organ at its posterior border where they end in three principal branches and terminate finally in the *Vena cava inferior*. It is evident from what has already been stated that the system of capillaries formed by the hepatic artery and portal vein, must ultimately form a union to permit of the flow of their blood into the hepatic vein and thus into the general venous system of the body.

The course of the hepatic artery through the liver points to its physiological significance more as a nutrient vessel to the hepatic tissues than as an accessory to the production of bile; its branches are accompanied by those of the portal vein and bile-duct, to the coats of which, as well as to the adjacent connective tissue, it supplies nutrient vessels known as *rami vasculares*. It also sends branches to the fibrous covering of the liver (*rami capsulares*) where it forms a wide-meshed capillary system, the veins of which terminate in the portal system. A third set of branches (*rami lobulares*) pass into the lobules of the organ where their terminal capillaries are very peculiarly arranged; and to this portion may be ascribed a participation of the hepatic artery in the biliary function of the liver; the *rami lobulares* pass into the peripheric portions of the lobules, and their capillaries join the capillary network of the lobule intermediately between those of the hepatic vein and portal system. Thus, if it were possible to make a perfect injection of the hepatic artery with a colour different from those used in the injection of the hepatic vein and portal vein, its capillary system in the lobules would be seen to join the other capillaries at the junction of the blue and red in the illustration.

The *portal vein* from its course through the liver suggests its function as pre-eminently the elaborator of bile; it passes into the organ alongside the hepatic artery and bile-duct to terminate in numerous branches situated between the lobules—the *venae interlobulares* (KIERNAN*) or *venae peripherice* (GERLACH†). A slight difference obtains in different animals in the precise arrangement of these interlobular twigs of the portal vein; in the human being and cat they form short loops surrounding the lobules, in the rabbit these loops are very much longer, whilst in the pig they take on the character of regular rings. From these interlobular vessels a most complicated set of capillaries arises either directly from the interlobular twigs, or from finer branches which they give off; these capillaries open on the one hand into those of the *rami lobulares* of the hepatic artery, and on the other into the system connected with the hepatic vein. The capillary vessels according to FREY‡ measure from 9μ to 12.6μ in diameter, and the meshes of the dense network in the human subject vary from 22.6μ to 45.1μ ; these meshes are either circular, oval, squarish, triangular, or irregular in contour, and generally have their long axis verging towards the central point of the lobule.

* *Philosophical Transactions of the Royal Society*, London, 1833.

† *Handbuch der allgemeinen und speciellen Gewebelehre*, Mainz, 1848, S. 280, *et seq.*

‡ *The Histology and Histochemistry of Man*, translated by A. E. J. BARKER, London, 1874, p. 504.

The *hepatic vein* is formed by a convergence of the dense capillary network, in which the hepatic artery and portal vein terminate at the periphery of each lobule, which joining to form fine blood-vessels enter a central lobular system. To this system KIERNAN* has applied the term *venæ intralobulares*, and GERLACH† has called them *venæ centrales*. These intralobular central veins open into larger vessels, the *sublobular veins*, upon which the lobules thus come to rest. If one of these sublobular veins be opened its thin walls permit the polygonal areas marked out by the lobules to be viewed with great distinctness; in such a dissection the centre of each lobule may be seen to be pierced by a dark spot—the opening of an intralobular vein. The walls of the capillaries are so very delicate that they can only be detected with great difficulty. If a very thin section of a carefully hardened liver be brushed gently with a fine soft hair pencil so as to remove the hepatic cells, a delicate network of tissue will be revealed; this tissue, as has already been stated‡, consists of the sustentacular tissue of the liver, together with the capillary network; the latter is revealed by the presence of the nuclei of their cells, and may be best demonstrated in the liver of young animals; in the adult condition these appearances are not so well marked; the connective tissue and capillary walls are apparently fused together, although in reality they remain distinct from one another (BEALE**).

The BILE-DUCTS.—The biliary system of the liver terminates in a duct, the *hepatic duct*, which, uniting with the *cystic duct* from the gall-bladder, forms a *common bile duct* which opens finally into the duodenum. According to HENLE, the walls of the gall-bladder are formed of layers of connective-tissue and non-striated muscular fibres alternately disposed; the muscular fibres decussating in all directions; the mucous membrane is arranged in regular folds, and is lined by a layer of columnar epithelial cells. From the cystic duct numerous follicles are given off which are indefinitely disposed or may obtain in rows; these mucin forming glands are of commonest occurrence at the inferior portion of the cystic duct, in the hepatic duct, and common bile duct; they are more sparingly found in the gall-bladder, and may be traced as far as some of the larger interlobular ducts within the liver. By some observers they are looked upon as simple diverticula of the biliary system, and not as special glandular structures. It is comparatively easy to trace the course of the hepatic duct within the liver, when that system has been successfully injected; its ramifications may be traced alongside the branches of the portal vein to an interlobular system from which a network of thin-walled biliary vessels take their rise; beyond this it becomes a matter of extreme difficulty to trace them to their ultimate terminations. In well stained uninjected sections, the walls of these interlobular bile-ducts may be seen to consist of a fine fibrous coat of connective tissue bearing a layer of columnar cells; with a high power of the microscope these cells exhibit a clear striated border, and well-defined oval nuclei. In the larger ducts a distinct mucous membrane may be observed, and it has been stated that a layer of unstriped muscular fibres also exists in their walls.

* Loc. cit.

† Loc. cit.

‡ See Ante. pp. 84, 85.

** *Phil. Trans., Roy. Soc., London, 1856.*

From the interlobular bile-ducts a very delicate network of tubes may be traced between and around the hepatic cells. The true characters of these *bile-capillaries*, and their relations to the blood-vascular and cellular elements of the liver, have given rise to the most varied opinions amongst histologists. The results of their investigations may, however, be briefly summarised in what is now generally accepted. The meshwork of bile-capillaries pass between the hepatic cells so as to come into close contact with their faces at various parts; the vessels are extremely fine, they have been measured in the rabbit by FREY*, who assigns to them a diameter of from $1.8 - 2.5\mu$. The meshes take on a somewhat cubical arrangement corresponding on an average with the size of the hepatic cells, and being slightly smaller than those of the blood-capillaries; in the rabbit the breadth of the meshes varies from $14.4 - 20.1\mu$.

The bile-capillaries do not come into direct contact with the blood-capillaries; there is always a small portion of hepatic matter between them, so that the secreting cell is placed in an intermediate position (ANDRÉJEVIC**). MAC GILLAVRY†, however, supposes that they are interlaced in such an intricate manner that the biliary radicles do sometimes lie against the blood-vessels. A consideration of the structure of the liver in the lower vertebrates shows that ANDRÉJEVIC's view is probably the correct one, for HERING‡ and EBERTH§ have pointed out that in the lower animals one or two rows of hepatic cells may intervene, and that in the higher vertebrates there always is a whole or a portion of an hepatic cell between the biliary capillary and the blood-vessel. In sections of hardened liver the bile-capillaries may be seen to originate between the hepatic cells in the form of minute spaces. By some these are regarded as forming a lacunar network, but there is no doubt that the biliary ducts in their ultimate distribution, do possess walls as first noted by MAC GILLAVRY, and subsequently confirmed by EBERTH. CHRZONSCZEWSKY|| also, by his method of natural injection, has clearly demonstrated the existence of a delicate envelope around the bile-capillaries, and the general relations of the biliary system to the hepatic cells and blood-vessels.

THE LYMPHATIC SYSTEM of the liver is manifested in form of a superficial and a deep set of vessels. The *superficial lymphatics* lie in the deepest layer of the peritoneal investment of the organ, and consist of a network of fine canals from which large efferent vessels pass off in all directions; those on the upper surface communicate with the thoracic glands after passing through the ligaments of the liver. The subperitoneal plexus, which is in direct continuity with the deeper lymphatics which emerge at the portal fissure, opens into the lymph nodes at that fissure, and near the gall-bladder. The *deep lymphatics* enter the organ along with the hepatic arteries, portal veins, and bile-ducts, and with them are enveloped in the fibrous sheath of GLISSON's capsule. They surround their accompanying vessels with a delicate network, and continue as distinct vessels until they reach the interlobular regions; thereafter they may preserve

* *Handbuch der Histologie und Histochemie des Menschen*, Leipzig, 1876.

** *Sitz. d. k. Akad.*, Wien, 1861, Bd. xliii. Abth. i, S. 379.

† *Sitz. d. k. Akad.*, Wien, 1865, Bd. i, Abth. ii, S. 207.

‡ *Sitz. d. k. Akad.*, Wien, 1866, Bd. liv, Abth. i, S. 335.

§ *Virchow's Archiv*, Berlin, Mai, 1867, Bd. xxxix, S. 70.

|| *Virchow's Archiv*, Berlin, Jan., 1866, Bd. xxxv, S. 153.

their vascular character to a limited extent, but obtain chiefly in form of perivascular channels which invest the blood-capillary system of the lobules (MAC GILLAVRY*), and whose external boundaries are determined by the delicate sustentacular tissue which supports the bands of hepatic cells (FREY†). In the liver of the pig, KISSELEW and CHRZONSZCZEWSKY have moreover succeeded in demonstrating a number of lymphoid follicles in connection with the interlobular lymphatic system.

THE NERVES of the liver are derived from the *plexus coeliacus*, and from the *vagi*, more particularly from the left vagus. They enter the substance of the liver, chiefly associated with the hepatic artery, at the transverse fissure of that viscus, and are distributed throughout the organ to its blood-vessels and bile-ducts. The ultimate terminations of the nerves have not yet been satisfactorily determined, and their entire physiological action is still an enigma. It is true that PFLÜGER‡ has stated that he has traced nerve fibrils into the substance of the hepatic cells, where he supposes that they terminate; but although this is highly probable, it has not yet received any support from the confirmatory evidence of competent observers.

METHODS OF PREPARATION.

CHRZONSZCZEWSKY'S METHOD OF NATURAL INJECTION.—By a series of carefully conducted experiments on living animals, CHRZONSZCZEWSKY was enabled to contribute very largely to our knowledge of the anatomy and physiology of the liver. He succeeded in injecting the bile-ducts throughout their course in the lobules, by introducing a solution of sulph-indigotate of soda in repeated doses into the circulation of dogs and sucking-pigs through the jugular vein, and killing the animals after an hour and a half had elapsed. He then washed out the blood-vessels of the liver by means of a solution of chloride of potassium injected through the portal vein, or filled them with a gelatine and carmine mass. On cutting sections of the liver, the bile-ducts were found to be perfectly injected with a blue colour, and the blood-vessels filled with red; the method when successfully carried out enabled him to verify ANDRÉJEVIC'S statement that the bile-capillaries are separated from the blood-capillaries by a variable amount of hepatic matter, and that the bile-capillaries are bounded by a delicate wall, and do not exist as mere intercellular passages, thereby adding weight to the conclusions of MAC GILLAVRY. By killing the animals sooner, he found the blue pigment partially within the hepatic cells, and thus proved directly that the cells are the active agents of secretion within the organ, and that they extract matters from the blood-vascular system and transmit them to the hepatic system. By a modification of these experiments, he elucidated the quantitative value of the separate systems of circulation, and showed exactly what share is taken by the hepatic artery and portal vein in the cholapoietic function of the liver; thus by tying the portal vein he found that the biliary system at the peripheral portions of the lobule was coloured, whilst the centres of the lobules remained colourless, and by tying the hepatic artery

* *Loc. cit.*

† *Handb. d. Histol. u. Histoch. d. Mens.*, 5th ed. Leipzig, 1876.

‡ *Archiv für Physiologie*, Bd. iv, p. 53.

he induced an exactly opposite result. From these experiments, he also deduced a most important physiological fact ; he showed that the circulation of the blood within the liver must take place very slowly, for when the portal vein was ligatured, *all* the blue colouring matter was deposited in the peripheral bile-ducts of the lobules, thus proving the tardy character of the movement of the blood, which had it been otherwise would certainly have carried the pigment towards the centre of each lobule.

METHOD OF INJECTING THE PORTAL VEIN AND HEPATIC VEIN.—The freshly killed animal ought to be bled, and its vascular system washed out with a $\frac{3}{4}$ per cent. solution of sodium chloride. The liver should then be injected *in situ* through the portal vein with a blue, and the hepatic vein with a carmine, gelatine mass ; the amount of the injection to be used must be judged by the external appearance of the lobules. The organ should then be detached, hardened in a two per cent. solution of potassic bichromate, or in alcohol, the sections cut, and mounted in Canada balsam.

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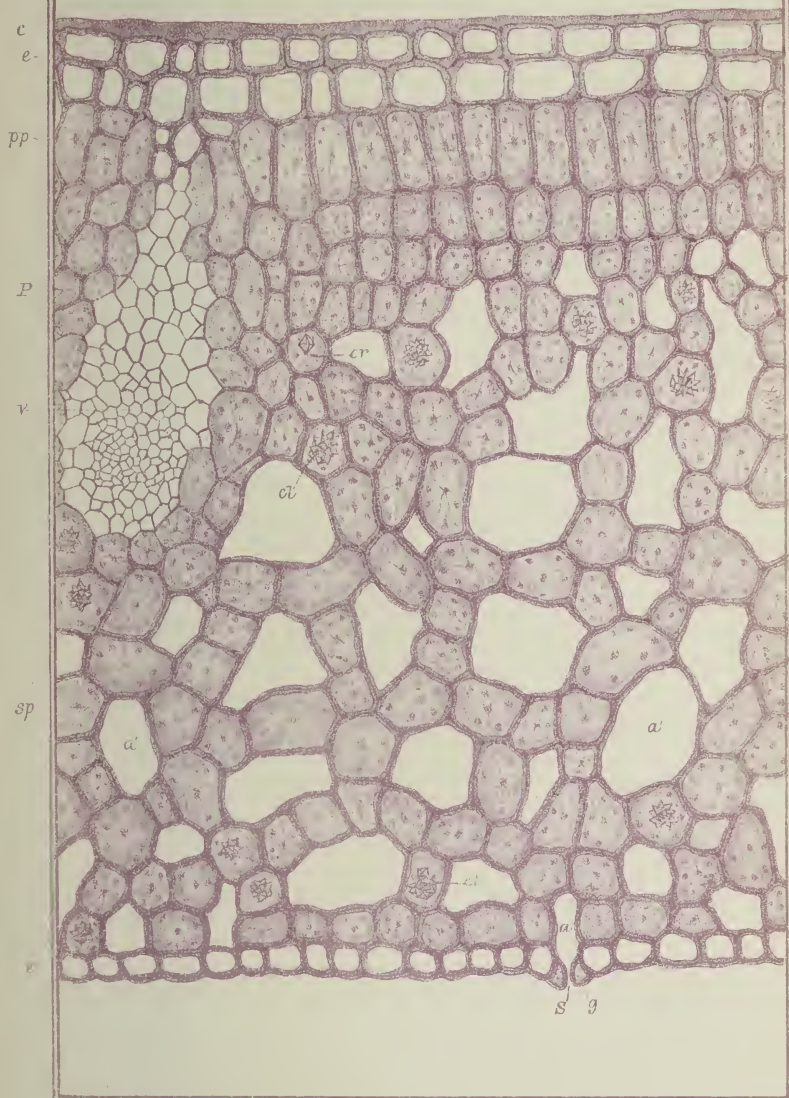
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T. V. S. OF A LEAF.
 Rhododendron Ponticum.
 X 333.

T.V.S. OF A LEAF.

RHODODENDRON PONTICUM.

Stained Logwood.

× 333 diameters.

Etymology.—LĒAF, *n.*; *pl.* LĒAVES. [O. Eng. *leaf*, A-S. *leaf*, O. Sax. *lōf*, *lōbh*, O. Fries. *laf*, D. *loof*, Icel. *lauf*, Sw. *lōf*, Dan. *löv*, Goth. *laufs*, O. H. Ger. *loup*, N. H. Ger. *laub*, allied to Lith. *lāpas*]. (*Botany*). The term leaf, in its strict application, is given to any appendicular organ of the stem; leaves are therefore distinguished into varieties, and are known as *seed-leaves* or *cotyledons*, *covering-leaves*, *foliage-leaves*, and *floral leaves*. In its ordinary sense, however, it is more particularly applied to the foliage-leaves.

RHŌ'DO-DĒN'DRON, *n.* [Gr. *ῥόδονδενδρον*, a rose-tree, from *ῥόδον*, rose, and *денδρον*, tree]. (*Botany*). A genus of evergreen shrubs or small trees, remarkable for their rose-coloured or purple flowers.

PŌN'TICUM, *a.* [Lat. *Ponticus*, Gr. *Ποντικός*, from *pontus*, *πόντος*, the sea, especially the Black Sea]. Belonging to the Pontus, Euxine, or Black Sea.

DESCRIPTION.

THE MEGASCOPIC CHARACTERS OF THE LEAF.—In its highest state of development the foliage-leaf consists of three primary parts,—a *sheath*, a *stalk* or *petiole*, and a *blade* or *lamina*. It very often happens, however, that one or other of these parts is suppressed.

The Mode of Arrangement of Leaves upon the Stem.—That part of the stem from which the leaf arises is termed its *insertion*, and its organic centre the *point of insertion*; when defoliation takes place, the plane of insertion is left as a *scar* or *cicatrix* upon the stem. Leaves are given off from the stem at parts termed *nodes*, the intervals between which are the *internodes*; when the internodes are short, the leaves become crowded, as at the terminal buds of all plants, and as the permanent condition of many others; when more than one leaf arises from the same level on the stem, the arrangement may be *opposite*, *decussate*, or *verticillate*; when only one leaf obtains at each node, the phyllotaxis is said to be *alternate* or *scattered*. It may be observed that however irregularly these last may be placed upon the stem, there is in reality, a definite law applicable to each case, which is so constant that it is of specific value; thus, in passing from one leaf to another which is placed exactly in a line vertically over it, a certain number of leaves are passed in a definite number of circuits made around the stem during the whole cycle, and the phyllotaxis of the plant is numerically represented by a fraction; for instance, one of the commonest modes of arrangement is the 2-5th form, which is in-

tended to convey the idea that in passing around the stem from one leaf to the next one vertically above it, two complete spiral circuits have been made around the stem, and five leaves included in the cycle thus taken. The law of phyllotaxis comes to be one of great importance, when the general configuration of the plant is considered ; for it applies not merely to the foliage-leaves, but through them to the direction of growth of the branches, which in phanerogamic plants always takes place from the axils of the leaves, and in mosses and many ferns immediately below or by the side of the leaves. This axillary development of branches in the higher plants is well shown amongst the *Labiatae* in consequence of their regular arrangement. In its practical application the law of phyllotaxis is often difficult to follow, and for two reasons ; the spiral upon which the leaves are arranged may sometimes be dextral, sometimes sinistral, and occasionally, as in grasses, both ; the leaves also may be very closely crowded together, as in some *Coniferae*, and thus render the knowledge of the order of their succession a matter fraught with difficulty.

The Intrinsic Characters of Leaves.—The *leaf-sheath* is not always developed ; it usually takes the form of a hollow tube, which embraces the stem at the insertion of the leaf. In grasses it is split in front, in sedges and rushes it forms an entire tube, whilst in many *Umbelliferae* it is split in front, and greatly inflated. In *Polygonum* it is peculiar, in that it bears the leaf on its back instead of at its upper end, and to this form of leaf-sheath the term *ochrea* has been applied. In many plants it takes the form of leaf-like appendages termed *stipules*, which are situated at the base of the leaf, and may become very variously modified ; they may remain as two small leaves adherent to the petiole, or adnate to each other at its base, as in the rose, or they may run down on each side of the petiole or stem, giving those parts a winged appearance,—the *decurrent* stipules of *Vicia Sepium* ; in the violet they form large leaf-like expansions, sometimes larger than the rest of the leaf ; in *Lathyrus Aphaca* this form is carried to an unusual extent, the blade of the leaf is reduced to a mere tendril, whilst its stipules form foliar organs at its base ; in the beech and oak the stipules are membranous and deciduous, whilst in *Gleditschia* they take the character of spines, and in others form single cirrhi ; in grasses the sheath, at its junction with the leaf-blade, forms a delicate prolongation, or stipule, which is called a *ligule*.

The *petiole* or *leaf-stalk* does not always exist. It usually articulates the leaf to the stem at the part of insertion ; sometimes its articular end is greatly enlarged and after defoliation remains attached to the stem, it is in that case called a *pulvinus*. The leaf-stalk may be greatly elongated or short, and may become very variously modified in shape ; thus it may be cylindrical, subcylindrical, fluted or grooved, flat, or foliate. When it becomes leaf-like in form, as in *Acacia melanoxylon*, it is termed a *phyllode*. When leaves are devoid of a leaf-stalk they are said to be *sessile*, and their mode of attachment to the stem has given rise to the following nomenclature. The term *amplexicaul* is given to those leaves whose lamina surrounds the stem in its insertion, *semi-amplexicaul* when only half or a portion of the circumference of the stem is embraced by the lamina (*Thlapsi perfoliatum*). When the opposite margins of the base of the leaf encircle the stem and unite on the other side as in

Bupleurum rotundifolium, the leaf is called *perfoliate*, and *connate* when two opposite leaf-blades unite to encircle the stem (*Lonicera Cuprifolium*). When the lamina of the leaf at its insertion is prolonged down the stem, the latter is said to be *winged*, and the leaf *decurrent*. The petiole is usually inserted at the lower edge of the blade of the leaf; when it is inserted on its under surface the leaf is termed *peltate*.

The *blade* or *lamina* of the leaf is the most important part of that structure, and the variation of its form is usually taken as the chief item in the description of leaves. When it is single and attached to the stem or petiole by one articulation only it is termed a *simple*, and when it is divided into a number of parts or leaflets, each of which is separately articulated, it is called a *compound* leaf. Numerous technical names have been applied to the external forms taken by leaves of which the following are the most important:—The general shape of the leaf may be *linear*, as in grasses, where the breadth of the leaf varies but slightly from its base to its apex, and its length exceeds its breadth by many times; a linear leaf which at the same time is rigid as in *Iris* is termed *ensiform*, and when pointed as in most *Conifere* is called *acicular* or *acero**se*. When the blade is about four times as long as it is broad, and terminates in a more or less pointed apex it is said to be *lanceolate* (*Rhododendron*) and *oblong* when the ends are equally rounded off; under the same conditions a shorter leaf is called *oval* or *elliptical*; *ovate* when it is egg-shaped and the broadest end at the base; to the opposite of this the term *obovate* is given. The terms *cordate*, *obcordate*, *orbicular*, *sub-rotund*, *reniform*, *rhomboidal*, *triangular*, *hastate*, and *sagittate*, are all applied to forms of leaves in their ordinary signification. The shape of the apex and base of the leaf is often characteristic, and to these the terms *cuneate*, *spathulate*, *obtus**e*, *acute*, *acuminate*, *mucronate*, *truncate*, *emarginate*, *obcordate*, etc., are applied. The margin of the leaf also is taken into account in its general description, and is said to be *entire* when it is free from notches of any kind, *dentate*, *serrate*, *biserrate*, *crenate*, *repand* or *wavy*, *ciliate*, *spiny*, *scabrous* or *rough*. When the margins are more deeply cut than the terms already noted imply, they may be described as *incised*; if the divisions extend inwards so as to nearly reach the central midrib of the leaf the structure is termed *pinnatisect*, *pinnatifid* when they reach only half way between the margin and the median line and *pinnatipartite* when they are still less marked; the terms *palmatisect*, *palmatifid*, and *palmatipartite* are similarly employed to indicate that the incisions take a somewhat oblique downward course towards the base of the leaf. A peculiar form of *pinnatifid* leaf called *runcinate*, is to be found in the dandelion, where the points of the large central divisions are recurved, and another modification where the terminal lobe is large and rounded is called *lyrate*, as in *Brassica alba*. In those cases where the incision of the leaf is carried to a still greater extent and the leaf is cut irregularly into numerous narrow parts the term *laciniate* is applied. A leaf is said to be *slit* when its margins are divided into narrow pointed parts, *lobed* when those parts are large broad and rounded, and *sinate* when the lobular character is broader and the incisions shallower and rounded off.

Compound leaves are of two chief varieties—*digitate* and *pinnate*. In the *digitate* form several leaflets, usually 3, 5, 7, and occasionally 4, are

inserted at the end of the leaf-stalk, and the leaf is said to be *ternate*, *quadrinate*, *quinate*, etc., or if further sub-divided, *binate*, *tri-ternate*, etc.; a special form in which the petiole divides into two parts, each one bearing its own leaflets, is called *pedate* (*Helleborus*). In the pinnate variety the primary petiole is greatly elongated and is called the *rachis*, from this secondary petioles (*petiolules*) are given off, which bear the leaflets. If the rachis terminates in a solitary leaflet, the whole system is called *imparipinnate*; if an equal number of leaflets are disposed on each side of the rachis, it is altogether termed a *paripinnate* leaf, and it usually happens in this form that the rachis either ends abruptly or in a point or a tendril. Each pair of leaflets is called a *jugum*, and the leaf may thus be *bi-jugate*, *tri-jugate*, and so on; or the leaflets may be alternately arranged and may be consecutively large and small (*interruptedly pinnate*). When the leaf becomes more complex the leaf may become *bi-pinnate*, *ter-pinnate*, &c.

In texture leaves are said to be *herbaceous* when they are of firm consistency, but last for only a season; they are *coriaceous* or *leathery* in most evergreens, *succulent* and *fleshy* in such leaves as those of the cabbage, aloe, etc. In shape they are called *symmetrical* when the parts on each side of the mid-rib are nearly equal as in most leaves; *unsymmetrical* as in *Begonia*, etc. It also happens that leaves of more than one form are found on the same plant, which is then termed *heterophyllous* (*Ranunculus aquatilis*, *Capsella*, etc.) The venation of leaves is caused by the disposition of the fibro-vascular bundles within them, the principal vein is called the *mid-rib* and usually traverses the centre of the leaf; from it branches arise which ramify in all directions (*reticulately-veined leaves*) or the larger of these have a tendency to lie side by side (*parallel-veined leaves*).

The modifications which leaves undergo are sometimes exhibited in the form of *tendrils* (Vetch, Pea, etc.), and *Spines* (Holly); in *Nepenthes* the lamina is converted into an *ascidium* or pitcher.

THE MICROSCOPIC CHARACTERS OF THE LEAF.—The foliage-leaf of *Rhododendron Ponticum* has been chosen as the subject of this illustration, because a transverse vertical section of the blade affords a remarkably good type of leaf-structure. The section has been stained with logwood and mounted in Canada balsam, and as a consequence of this method its cellular outlines have been rendered perspicuous. The superficial layer of the *upper epidermis* *e* has united to form a kind of *cuticular expansion* *c*, and the under surface of the leaf is bounded by its *epidermis* (*hypodermis*) *é*. Between these two limits the cells are characteristically arranged; *pp*, the *pallisade parenchyma* is constituted by a row of closely apposed columnar cells, and is seen to pass by a gradual transition through a less compactly constituted zone of parenchymatous cells *P*, to a loosely disposed area of *spongy parenchyma* *sp*, so termed because numerous *inter-cellular air-spaces*, *á*, obtain in that situation. At *v* the position of a vein is shown, and is seen to be constituted by a closed fibro-vascular bundle.* The whole leaf is thus seen to be composed of a parenchymatous tissue, traversed by a system of closed fibro-vascular bundles; all the cells con-

* See this Journal, pp. 12—14, 17, 31.

tain a number of chlorophyll bodies, with the exception of the epidermal cells and the vessels; but the upper surface of the leaf is usually of a brighter hue than its lower portion, on account of the more compactly arranged subjacent cells. *S* marks the opening of a *stoma*, flanked on each side by a small *guard cell g*, which, unlike the cells of the surrounding epidermis, bears chlorophyll particles. The *stoma* leads into an *air cavity a*, which is in communication with the intercellular air-spaces so characteristic of the lower aspect of the leaf. Many of the cells exhibit clusters of crystals of quadrate octahedra, composed of calcium oxalate *cl*, and occasionally a large solitary octahedron *cr*, of the same substance may be detected within some of the cells.

METHODS OF PREPARATION.

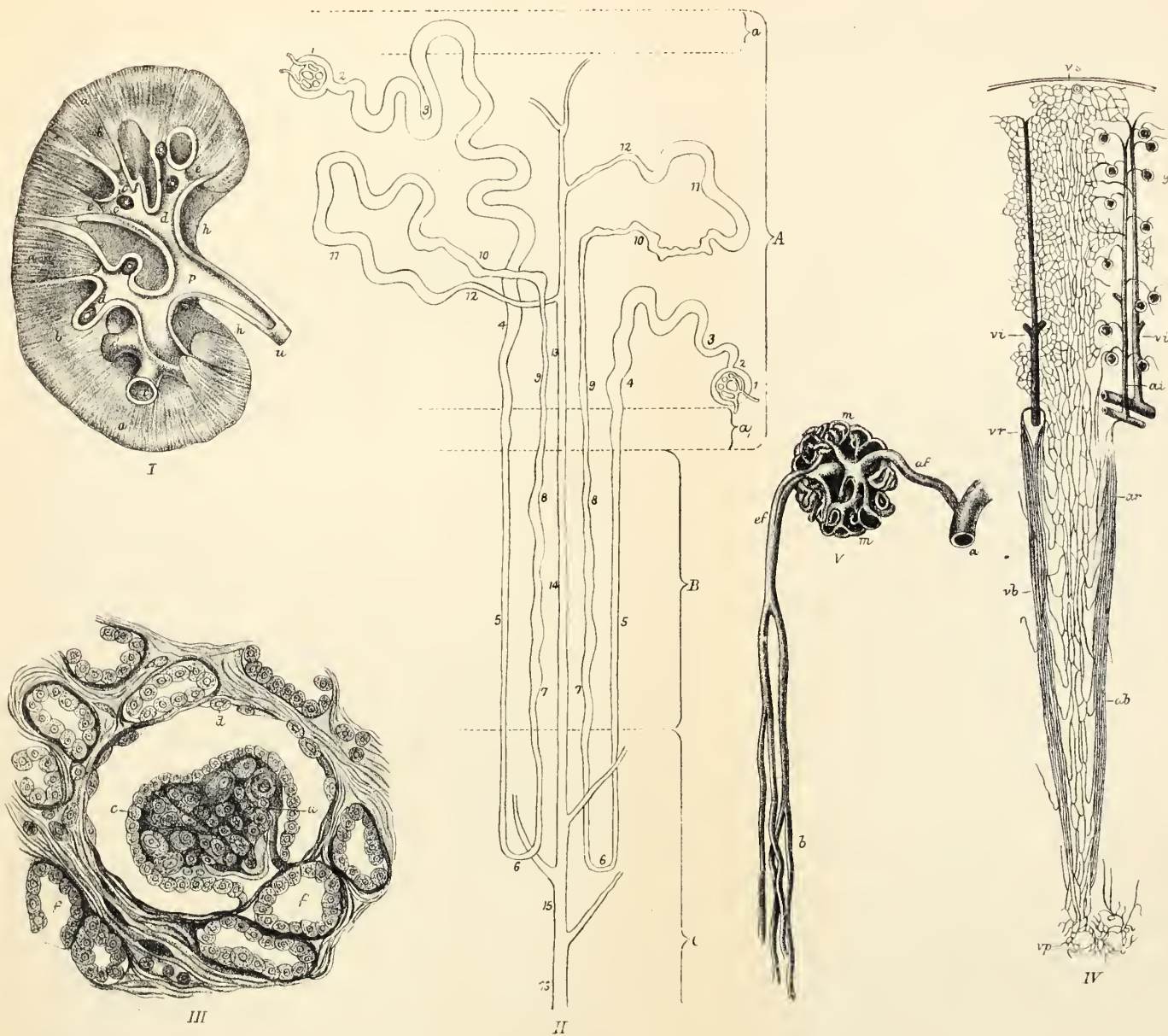
The method employed in the preparation of the sections from which the illustration was taken, consists in decolourising the leaf by means of alcohol previous to cutting the sections, staining in logwood, and mounting them in Canada balsam. See pp. 15-16, 85.

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HUMAN KIDNEY.
Diagrams.

THE KIDNEY.

ETYMOLOGY.—KID'NEY, *n.*; *pl.* KID'NEYS. [Probably from A—S. *quidh*, *cwidh*, Icel. *quidr*, O. H. Ger. *quiti*, Goth. *qvithus*, belly, womb, Eng. *nigh*, and Lat. *renes*, Gr. *νεφροί*, the kidneys]. (*Anatomy*).—Differentiated excretory organs which probably perform a renal function, or at all events are concerned in the elimination of the nitrogenous products of waste from the animal economy first make their appearance in the *Vermes*, in the form of a *water-vascular system* in some, and of *segmental organs* in others. Although no structure is discernible in the lower forms of life (*Protozoa*) to which a renal function may be assigned, still it is not improbable that that office is in part performed by the so-called contractile vacuoles which obtain in many of them.

In the *Echinodermata* excretory organs have not been satisfactorily made out; in the *Holothurideæ* canals have been observed in the body wall beset with infundibular organs, which open into the cœlom; ciliated organs have also been made out in connection with the dorsal canal of the arms of *Crinoidea*, and to these a renal function has by analogy been ascribed, as well as to the water-vascular system, inasmuch as it approaches in some respects (e. g. its communication with the exterior on the one hand, and with the blood-vascular system or what is practically the same thing, the cœlom, on the other hand) to the form of excretory apparatus in the *Mollusca*.

The organ of excretion obtains in three characteristic forms amongst the *Arthropoda*. The *green-gland* of the Lobster and Crayfish is regarded as a renal organ; it is lodged in the front part of the head of the animal, below the anterior aspect of the cardiac portion of the stomach, in a sac which opens by an excretory duct, the orifice of which is placed in the centre of a papilla situated on the basal joint of each antenna; the presence in this organ of guanin* adds weight to the statement that it is a renal organ. No such organ can be found in any of the adult *Entomostraca*, but they have been demonstrated in nearly all their larval forms. In the *Cirrepedia* they have probably become modified to subserve the requirements of their mode of life in the so-called *cement glands*. Another form of organ supposed to be renal, occurs amongst the lower *Crustacea*; it consists of a transparent looped arrangement situated in the pallial-like fold of the dorsal integument, and is known as the *shell-gland* (*Entomostraca*). The third variety obtains amongst the *Tracheata* as diverticula of the hind-gut of the enteric canal; they occur in form of long canals which may be simple or branched, and are often disposed in numerous coils around the alimentary canal; they have long been known as the *Malpighian vessels* or *urinary canals* (*Insecta*, etc.)

* WILL UND GORUP-BESANEZ, *Gelehrte Anzeigen d. k. Baienzschen Akademie*, 1848, No. 233.

The *Brachiopoda* resemble the *Annelida*, amongst the *Vermes*, in the possession of excretory organs which take on the character of looped canals (segmental organs); they open externally near the base of the arms, and taking a bent course communicate by funnel-shaped orifices with the cœlom.

On passing to the *Mollusca*, the excretory organs are found to be well marked and essentially homologous with the renal organs of some of the *Vermes*. In the *Lamellibranchiata* they form a paired-gland termed the *organ of BOJANUS*, which lies on the dorsal aspect of the body in the middle line close to the base of the branchiæ; it consists of a dark brownish or yellowish tissue, which encloses a lacunar system terminating in a large central space, and it communicates directly on the one hand with the exterior, and on the other with the blood-vascular system; the generative organs, moreover, are closely associated with it. The renal organ of the *Gasteropoda* becomes unilateral through the degeneration of one side of an originally paired system; as in the other *Mollusca*, it communicates by one pore with the pericardial sinus, and by another with the exterior. In the *Pteropoda* the similarity in the disposition of its orifices have marked out an organ of a very spongy texture (which in some instances is also a contractile organ) as the *kidney*; although it has not been shown as in the *Lamellibranchs* and *Gasteropods* that concretions of a urinary character occur here. In the *Cephalopoda* the *vena cava* divides into as many afferent vessels as there are gills; each of these branches traverses a chamber which is in direct communication with the mantle cavity, and the wall of the blood-vessel which thus comes into contact with the water at this part is greatly sacculated, and forms a glandular organ which thus comes to lie in this *renal chamber*. Amongst the products of excretion, it may be noted that *uric acid* has as yet been only detected amongst *Gasteropods* and *Cephalopods*.

"The higher *Vertebrata* are all provided with two sets of renal organs, the one existing only during the early foetal state, the other persisting throughout life."

"The former are the *Wolffian bodies*, the latter the true *Kidneys*."

"The *Wolffian bodies* make their appearance very early, on each side of the ventral aspect of the spinal region of the embryo, as small transversely-disposed tubuli, opening into a duct which lies upon their outer side, and enters, posteriorly, into the base of the allantois, and thence into the primitive cloaca with which that structure is connected. The *Wolffian duct* is one of the first-formed structures in the embryo, and precedes the tubuli."

"The *Kidneys* appear behind the *Wolffian bodies*, and, apparently, independently of them; their ducts, the *ureters*, are also distinct, but likewise terminate in the pelvic part of the allantois. Thus the urinary secretion passes into the allantois, and it is that portion of this organ which lies within the abdomen, and becomes shut off from the rest by the constriction and obliteration of the cavity of an intermediate part, and its conversion into the *urachus*, that gives rise to the *urinary bladder*. The ultimate secreting tubuli of both the *Wolffian body* and the *kidney*, are alike remarkable for ending in dilatations which embrace convoluted capillaries,—the so-called *Malpighian tufts*. Neither *Wolffian bodies* nor *kidneys* have been observed in *Amphioxus*. It is doubtful whether

true kidneys are developed in *Ichthyopsida*, or whether the so-called kidneys of these animals are not, rather, persistent Wolffian bodies." (HUXLEY*).

EXPLANATION OF PLATE.

DIAGRAMS OF THE KIDNEY.

FIG. I.—L. S. THROUGH THE PELVIS AND SUBSTANCE OF THE RIGHT HUMAN KIDNEY. (After QUAIN.) " $\frac{1}{2}$ natural size. *a*, the cortical substance; *b, b*, broad part of two of the pyramids of MALPIGHI; *c, c*, calices or infundibula of the pelvis laid open; *c'*, calyx unopened; *d, d*, summit of the pyramids or papillæ projecting into the calices; *e, e*, section of the narrow part of two pyramids near the calices; *p*, pelvis or enlarged portion of the ureter within the kidney; *s*, the sinus; *h*, the hilus; *u*, the ureter."

FIG. II.—DIAGRAM SHOWING THE COURSE OF THE RENAL TUBULES AND THEIR VARIATIONS IN THE DIFFERENT SECTIONS OF THE CORTEX AND MEDULLA. (After KLEIN, *Atlas of Histology*, p. 264). "A, cortex limited on its free surface by the capsule; *a* subcapsular layer not containing Malpighian corpuscles; *a'*, inner stratum of cortex without Malpighian corpuscles; B, boundary layer; C, papillary part next the boundary layer; 1, Bowman's capsule of the Malpighian corpuscle; 2, its neck; 3, proximal convoluted tubule; 4, spiral tubule of SCHACHOWA; 5, descending limb of Henle's loop; 6, the loop proper; 7, thick part of the ascending limb; 8, spiral part of the same; 9, the narrow ascending limb in the medullary ray; 10, the irregular tubule; 11, the intercalated section of SCHWEIGGER-SEIDEL, or the distal convoluted tubule; 12, the curved collecting tubule; 13, the straight collecting tubule of the medullary ray; 14, the collecting tube of the boundary layer; 15, the large collecting tube of the papillary part; in the papilla itself, not represented here, this tube becomes confluent with others and thus forms 16, the duct."

FIG. III.—DIAGRAMMATIC DRAWING OF MALPIGHIAN CORPUSCLE. (After KLEIN, Fig. 149, *Handbook for the Phys. Lab.*, $\times 350$ diameters). "*a*, glomerulus; *c*, epithelium covering the glomerulus; *d*, flattened epithelium lining Bowman's capsule; *f*, urinary tubules in section."

FIG. IV.—DIAGRAM OF BLOOD-VESSELS. (After LUDWIG from Klein's *Atlas of Histology*.) "*a i*, interlobular artery; *v i*, interlobular vein; *g*, glomerulus of Malpighian corpuscle; *v s*, vena stellata; *a r*, arteria recta; *v r*, vena recta; *a b*, bundle of arteriolæ rectæ; *v b*, bundle of venæ rectæ; *v p*, network of vessels around the mouth of ducts."

FIG. V.—INJECTED GLOMERULUS FROM THE INNER PART OF THE CORTICAL SUBSTANCE OF THE KIDNEY OF A HORSE, $\times 70$ diameters. (After BOWMAN, *Phil. Trans.*, 1842). "*a*, interlobular artery; *a f*, efferent artery; *m, m*, convoluted vessels of the glomerulus; *e f*, efferent or straight arteriole; *b*, its subdivision in the medullary substance."

DESCRIPTION.

THE MEGASCOPIC CHARACTERS OF THE HUMAN KIDNEY.—In external shape the human kidney is so characteristically developed that the term reniform which has been named from it is constantly employed in ordinary language to denote a form which is kidney-like, and resembles a bean in its general outlines. The organ is closely invested by a thin strong fibrous coat, the *tunica propria*, which is loosely attached to its substance by a very delicate areolar tissue and minute blood-vessels; on reaching the *notch* or *hilus* (*h*. Fig. I.) the tissue of this coat becomes continuous with the external surface of the infundibulum formed by the dilated portion of the emergent *ureter* (*u*.), and the adherent nutrient blood-vessels, etc., which enter at this part. A longitudinal section such as that represented by Fig. I., when looked at without the aid of a mag-

* *Anatomy of Vertebrated Animals*, London, 1871, pp. 94, 95.

nifier, shows an external hollowed portion which dips down around the infundibulum from the hilus, and is termed the *sinus* (*s.*) The emergent ureter is greatly dilated, just before it leaves the organ, by the confluence of its primary sub-divisions, and the chamber thus formed is termed the *pelvis* (*p.*) From the *pelvis* prolongations of the ureter are seen to pass into the substance of the organ, and to terminate abruptly in cup-like depressions the *calices* (*c.*); into these calices little conical protrusions depend (*d.*), and are the summits of pyramidal structures,—the Malpighian pyramids, which lie apposed to one another, and together constitute the substance of the organ. If the ends of these pyramids which thus project into the calices be carefully examined, they will be seen to be perforated by numerous orifices,—the openings of the uriniferous tubules. An ordinary lens reveals, further, that the interspaces between the pyramids are occupied by septa of tissue to which the name *columnae Bertini* has been applied. The substance of the kidney is further roughly divisible into two portions, an inner pale *medullary*, and an outer reddish-brown *cortical* layer. The difference in appearance of these layers is traceable to a difference in the disposition of the various parts which build up the structure, and which can only be fully considered under the microscope.



del. ad nat.

Wheat (Triticum aestivum) L. 1845

AECIDIUM COMPOSITARUM.

Variety Tussilaginis.

X 70

V. S. OF CLUSTER CUP.

ÆCIDIUM COMPOSITARUM.

Variety *Tussilaginis*

In situ on the leaf of *Tussilago Farfara*.

× 70.

Etymology.—CLÜS'TER, *n.* [A-S. *cluster*, *clyster*. Cf. Sw. and Dan. *klase*, a cluster of grapes, and D. *klissen*, to be entangled]. A number of things of the same kind growing, joined, or associated together.

CUP, *n.* [A-S. *cupp*, *cuppa*, *copp*, D. and Dan. *kop*, Sw. *kopp*, Ger. *kopf*, Fr. *coupe*, Pr., Sp., and Pg. *copa*, It. *coppa*, L. Lat. *cuppa*, cup, from Lat. *cupa*, *cuppa*, tub, cask, etc., for holding liquids. Cf. "COOP"]. A small vessel commonly used to drink from, a chalice.

DESCRIPTION.

In almost any part of England where the COLT'S FOOT (*Tussilago Farfara*) is found growing, its parasitic CLUSTER CUP (*Æcidium compositarum*, variety *Tussilaginis*) may be discovered flourishing during the warmer periods of the year. The cluster cups themselves form somewhat circular bright orange patches of growth on the under surface of the leaf, whilst the *Spermogonia*, which represent certain phases in the cycle of their development, occur as small brownish specks on the upper surface of the leaf, usually immediately above the æcidium cups, and only recognisable after careful examination.

We are indebted to MR. ARTHUR J. DOHERTY, of Victoria University, for the excellent specimens in our possession which he gathered during the month of June near Buxton.

The presence of this parasitic fungus is very easily detected upon its host; even at a distance the large leaf of the Colt's foot may be seen to be spotted over the greater portion of its upper surface with purplish-brown spots; on turning the leaf over, bright orange coloured circular groups are revealed, which upon still closer examination are seen to be composed, in fully matured specimens, of an aggregate of minute cups, whence its name of cluster cup. Each cup is filled with a rich orange coloured powder which when immature is of a purplish-green hue.

THE MICROSCOPIC CHARACTERS OF THE CLUSTER CUP.—If a thin vertical section be made through one of the groups of cluster cups and examined under a power of about 70 diameters, the appearances figured in the illustration will be observed. Wherever the parasitic growth has taken place, the tissues of the vegetable host have become hypertrophied, and this abnormal development has taken place to such an extent that the tissues have become almost twice as bulky as they

would have been under ordinary circumstances.* In minutely observing the changes produced in the different parts of the structure, we find before us an undoubted demonstration of the great law of cellular pathology which was first prominently enunciated by VIRCHOW† with regard to animal tissues; viz., *that the germinal activity of cells is increased by a moderate stimulation, but that excessive irritation profoundly alters them and results in their destruction.* With a power of about 100, and better still with one of 500 diameters, all the cells of the infested tissues are seen to be penetrated by a network of hyaline mycelial filaments which branch dichotomously, are septate, and measure about $\cdot 000082$ in. in diameter. In the specimen before us the æcidium fruits are matured, whilst the spermogonia exhibit signs of decay; in accordance with this, the cells of the leaf immediately surrounding the æcidia are found to be full of mycelial filaments; those in the neighbourhood of the spermogonia being almost devoid of that parasitic ingrowth; nevertheless the cells in both regions are abnormally developed, although in the vicinity of the spermogonia they are slightly less so than in contiguity with the æcidia. It is easy to understand why this should be the case, when the life history of the fungus is known, but before we pass on to developmental considerations, we may remark that where the cause of stimulation is great, but not too excessive, as in the cells which surround the æcidia, there the greatest amount of cellular increase takes place; near the spermogonia, on the other hand, we have an instance of gradual recovery of the cells towards their normal condition, due to the withdrawal of the irritating source, by the slow decay of the mycelium at that part; whilst immediately in contact with the basis of the æcidia, where the growth of the parasite is most vigorous and concentrated, the leaf cells show signs of degeneration. These pathological changes are manifested, not in an increase in the number, but in the enlargement of the individual cells. The cell walls do not seem to be much affected, and retain their normal thickness with but slight variations; in those parts where the irritation has been excessive they seem to split up into ragged laminae, probably caused by the intergrowth of mycelial filaments, before they ultimately break down into an incoherent granular mass; where the change is less marked, the lamellar degeneration can just be detected. The protoplasmic contents of the hypertrophied cells seem to have undergone profound changes; not only have they lost their characteristic arrangement within the cell walls and filled their entire cavities, but the penetration of the mycelium has induced a chemical change, or metabolism of the substance, which has resulted in the production of numerous minute highly refractive particles of a globular form and yellowish oily appearance; where the tissues have degenerated the protoplasm has of course been involved in the general destruction.

* It may be interesting to some of our readers to know upon what data we have based our statements; we therefore append a list of average measurements taken from a large number of specimens:—

Vertical height of normal leaf = $\cdot 025$ in.
 Vertical height of hypertrophied leaf = $\cdot 0425$ in.
 Approximate diameter of mature spermogonium = $\cdot 00787$ in.
 Approximate diameter of mature æcidium = $\cdot 0225$ in.
 Vertical height of basidium = $\cdot 005$ in.
 Diameter of peridium cells = $\cdot 00085$ in.
 Diameter of spores = $\cdot 0006$ in.

† *Cellular Pathology*, translated by CHANCE, 1860.

In the illustration two æcidia and one spermogonium are shown. The latter is situated on the upper surface of the leaf, has become mature and shows signs of decay. The former occur on the lower surface of the leaf; one of them has been fully developed, and has, as a consequence, ruptured the overlying epidermis, the other is shown still covered by the epidermal layer of the leaf. In order to understand the significance of these structures, and the relations they bear to one another, it would be desirable to follow them throughout their life history. The development of *Æcidium compositurum*, as far as the growth and maturation of its spermogonia and æcidia are concerned, is known, and corresponds in every essential detail with the course of events in other species of the same genus; but we have reason to believe, from the researches of DE BARY, ØRSTED, and others, that, in addition to all this, it passes through an entirely new and different phase of existence which has as yet been only satisfactorily made out in its ally *Æcidium Berberidis*. We shall therefore give a brief résumé of what has been observed in that plant, with a view to the complete description of a series of events which are as interesting as they are remarkable.

When DE BARY* employed the term *heterœcism* in his description of the growth and development of the *Uredineæ*, he abolished thereby the generic value of *Æcidium* and *Uredo*, by showing that they represent different forms of the same organisation whose individual peculiarities are traceable to the perpetuation of their existence on different hosts. Strictly, then, heterœcism would not be an appropriate term if a variation in the form of the plant obtained upon the same host, as it probably is the case with *Æcidium compositarum*, where different forms of spores do occur upon the same plant, although their derivation from one another has not yet been clearly demonstrated.

Æcidium Berberidis, the cluster cup of the common Barberry (*Berberis vulgaris*) usually infests the leaves of that plant during the spring months; it may be detected in the form of yellowish swollen patches on the under surface of the leaves. Its life history and anatomical characters may be summarised thus:—The germination of pre-existing spores, which under favourable conditions are transported by winds and other external agencies to the leaves of the Barberry in spring, gives rise, as in other fungi, to a tubular outgrowth, the *promycelium*, which bears three or four *sporidia* or rounded bodies; these become detached, give off *hyphæ* or filamentous prolongations which in their subsequent development form a densely matted *mycelium* of hyphæ in the shape of an urn amidst the parenchyma of the leaf, immediately below its upper epidermal layer. To the body thus produced, the name of *spermogonium* has been given. Concurrently with this formation, the surrounding tissues of the leaf are invaded by ramifications from the outer portion of the spermogone, which seem to branch dichotomously, become septate, and make their way through the tissues of their host, chiefly by means of the intercellular passages; but ultimately they penetrate the cell walls and enter the protoplasmic contents, evidently deriving nutriment therefrom, and at the same time producing certain chemical changes, which in their reaction stimulate the tissues to inordinate

* *Monatsber. d. k. Acad. d. Wiss.*, Berlin, 1865.

growth. The pabulum thus derived from its nurse, endows the little parasite with the vigour necessary for the formation of other elements, and ere long its cavity becomes the seat of activity in the production of other hypha-like filaments, which extend towards the centre of the urn, and thence bend upwards towards the external liminary layer formed by the epidermis of the leaf. The further growth of these hair-like filaments causes a disruption of the overlying epidermis, through which they project in the form of a brush. In addition to this, the bottom of the spermogonium is covered by similar mycelial outgrowths, the *sterigmata* or *basidia*, the apices of which become abstricted into narrow, rounded, rod-like bodies (*spermatia*), and eventually become detached, to fall into the cavity of the spermogonium. The continued formation and shedding of these spermatia, which vary in their major axis from $\frac{1}{6000}$ — $\frac{1}{12000}$ of an inch, at length fills the cavity of the spermogone with a granular looking mass the particles of which adhere to one another through the production of a colloid substance which envelops them. The action of water, as of rain, upon this substance causes it to swell, and thus to protrude through the orifice of the spermogone, where its continued solvent powers liberate the spermatia; and now the latter may be observed to exhibit vibratile motions, which, however, cannot be mistaken for the Brownian cyclosis inasmuch as it ceases on the application of iodine solution but persists in a solution of calcium chloride. All attempts to demonstrate the further anatomy of these minute bodies have proved unsuccessful; as no cilia have been detected, their movements cannot be accounted for, and the action of reagents has failed to reveal the presence of an envelope which resembles the so-called fungus cellulose; thus, the action of sugar and sulphuric acid colored them reddish-purple, whilst caustic alkali rendered them invisible on account of its solvent properties. It is extremely probable that these structures are in some way related to a sexual process, but what that process consists in yet remains to be determined; their maturity is followed by a gradual decay of the spermogone, the interparenchymatous mycelia of which in losing their activity, enable the surrounding tissues to partially recover themselves; but this decadence only heralds another outgrowth, which is supposed to be derived from the mycelium of the spermogone, and to which in its maturity the term *æcidium-fruit* has been applied.

The *æcidium-fruits* thus take their origin from the mycelium which gave rise to the spermogonia, and appear at first in the form of rounded bodies within the substance of the leaf, composed of a feltwork of mycelial hyphæ. The bottom of this parenchymatous mass becomes differentiated into a hymenial layer, whence arises a basidium-like portion, the whole being inclosed in the mycelial envelope. When mature the *æcidium-fruit* reaches the upper epidermis of the leaf through which it bursts in order to liberate its contents; and at this stage it may be observed that numerous aerial hyphæ have grown from the hymenial layer at the bottom of the cup-like structure, the free ends of which become abstricted into *spores*. These *acido-spores* remain attached to one another for a considerable time in moniliform series; their contents assume a bright orange colour, and it may be noticed that the first formed spores, which are situated at the free ends of the

exerted hyphæ or *sporangia*, are larger than those towards their proximal ends, and have become rounded in form; whereas the younger spores, on account of their being closely compacted, are somewhat polygonal in shape. The outermost layer of spores also are worthy of remark; they become greatly flattened and coalesce to form an enveloping membrane the so-called *peridium* of PERSOON. The cells of the peridium are so uniformly adpressed, that they are more or less regularly hexagonal in outline, and somewhat larger than the spores.

The spores formed in the æcidium-fruits on the leaves of the Barberry, do not germinate unless they are transferred to the leaves or stems of grasses, such as the wheat, etc.; there they send filaments through the stomata of their new hosts, and in from 6 to 10 days produce the well-known *uredo-fruits* known as the "rust." The *uredo-fruits* produce single-celled *uredo-spores* which are dispersed, and give rise to a second, and this to a third generation of *uredo-spores*, and so on throughout the summer months; but towards the autumn a new kind of double-celled spore arises; at first in association with the *uredo-spores*, but afterwards entirely alone in the form of black lines on grasses (e.g. *Puccinia graminis* of wheat). These *teleuto-spores* remain dormant during the winter, when the period of vegetation of their host ceases, and do not germinate until the spring, until favourable circumstances convey them to the leaf of the Barberry. Unlike the *æcido-spores*, however, their germinating filaments penetrate the tissues of the host indiscriminately, and do not merely enter at the stomata.

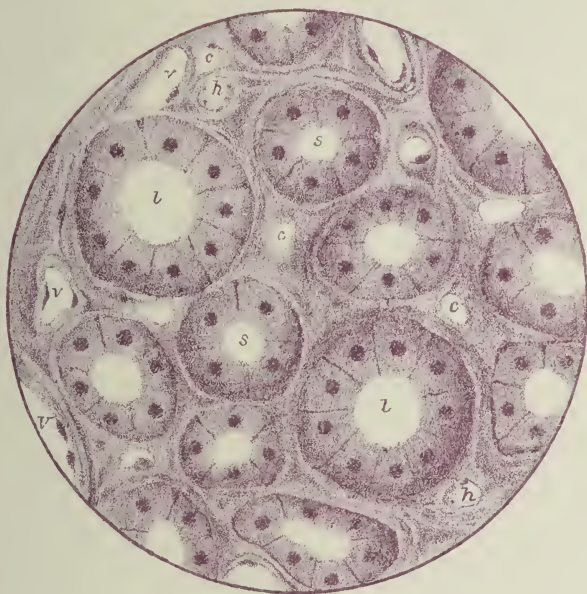
METHODS OF PREPARATION.

The freshly gathered leaf with the parasitic growth should be sliced before it has had time to decay; or should be preserved for future use in a 50 per cent. solution of alcohol. The sections may be mounted in glycerine, glycerine jelly, or in Farrant's liquid. If allowed to dry, the spores may be wetted with turpentine and mounted in Canada Balsam.

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del. ad nat.

West, Newman & Co. m.v.

HUMAN KIDNEY.
H. S. Papillary Portion.
X 400.

THE KIDNEY.

H. S. Through Medullary Layer.

Stained Logwood.

× 400 diameters.

- l.* Large collecting tube, *s.* Smaller collecting tube,
h. Tube of Henle's loop, *c.* Capillary blood-vessel,
v. Venous capillary.

Etymology.—KID'NEY, *n.*; *pl.* KID'NEYS. See p. 109.

DESCRIPTION.

THE MICROSCOPIC CHARACTERS OF THE HUMAN KIDNEY.—In intimate structure the human kidney consists essentially of a complex arrangement of tubules, the *tubuli uriniferi*, whose functions depend upon their characteristic association with the blood-vascular system, the whole being invested and supported by a sustentacular framework of connective tissue, and supplied with lymphatics and nerves.

THE CONNECTIVE TISSUE which forms the framework may, from the manner in which it is disposed in the various parts of the organ, be considered under the three following heads:—

1°. The *outer capsule* which envelopes the kidney consists of a layer of connective tissue, chiefly of the white-fibrous variety amongst which flattened connective tissue corpuscles may be detected with a high power by their deeply stained nuclei. Towards the periphery the tissue is very compactly arranged, but its deeper portion becomes slightly areolar, and the tenuity of its fibres increases as they dip down to become continuous with the intertubular tissue of the underlying cortex. It may be noted that in this downward course they pass chiefly together with the blood-vessels which run between the cortex and the capsule, and become mixed with a number of delicate elongated cells which EBERTH has described as a plexus of non-striated muscular fibres.

2°. The phrase *connective tissue of the parenchyma* may be taken as inclusive of the intertubular and the perivascular elements; and these vary in different parts of the organ. A delicate fibrous tissue spreads around the tubules of the cortex filling up the interspaces between them, and every here and there exhibiting a corpuscle whose well-marked oval nucleus defines its position (See Fig. III, p. 111). Its continuity with the capsular tissue has already been pointed out. In the region of the Malpighian corpuscles the connective tissue, with its corresponding corpuscles, becomes excessively delicate, and according to LUDWIG and

ZAWARYKIN* is always present to a greater or less extent; it becomes continuous with the tissue which surrounds the afferent arterioles, and thus with that of the interlobular arteries and the larger vessels of the medullary substance of which they are branches. From these the tissue may be traced around the arteriolæ rectæ into the boundary layer between the medulla and the cortex, where it becomes very scanty and assumes a hyaline honey-combed membranous aspect (KLEIN†), as the sustentacular substance of the tubules and capillary blood-vessels. The connective-tissue corpuscles in this position may be branched or spindle-shaped, and possess oval nuclei which are usually disposed transversely to the long axis of the tubules (SCHWEIGGER-SEIDEL‡). On reaching the papillary portion of the medulla, the connective tissue increases in quantity, and is more markedly fibrous; especially towards the apices where it merges into the superficial layer which invests the papillæ. Besides all this, the blood-vessels on their entry into the substance of the organ are accompanied by bands of longitudinally disposed muscular fibres, associated with an appreciable quantity of connective tissue, which takes its origin in the subjacent submucous tissue which will presently be noted, and which persists around those vessels until it is lost in the homogeneous tissue of the boundary layer.

3°. The free surface of the pelvis and calices (Fig. I, p. 111, p. c.), is, like the inner surface of the ureter, lined by a layer of stratified transitional epithelium which rests upon a membranous expansion formed of a dense meshwork of white-fibrous connective tissue and its corpuscles; this *mucous coat* passes by gradual transitions into a loosely arranged *submucous layer*, in which, at its inner aspect, longitudinal and circular layers of non-striated muscular fibres place it in continuity with the muscular coat of the ureter, and which obtain only as circular bands on the papillæ (HENLE§). Its outer more deeply seated portion bears a small quantity of adipose tissue; and a few elastic fibres may be detected in various situations throughout its extent.

THE PARENCHYMA OF THE KIDNEY consists of the *tubuli uriniferi*, which, in association with the blood-vessels, gives rise to the characteristic appearance of the substance of the organ. If a section such as that depicted in Fig. I, p. 111, be examined, two tolerably distinct regions may be recognised:—an inner part termed the *medullary*, and an outer the *cortical layer*. Of these, the former is further divisible into a *papillary portion*, and the *boundary layer*.

In most mammals the medullary layer is constituted by numerous converging lines terminating in a single conoid papilla, the apex of which is directed towards the hilus. In man, and in the pig, from 10 to 15 of these *pyramids of MALPIGHI* depend into the pelvis.

The papillary portion of each pyramid is uniformly marked by numerous vertical striæ, due to the straight course which the urinary tubules and blood-vessels take in passing to the apex of the papilla. The boundary

* *Sitz. d. k. Acad.*, Wien, Bd. xlviii, 1864.

† *Atlas of Histology*, London, 1880, p. 252.

‡ *Die Nieren des Menschen und der Säugethiere*, Halle, 1865.

§ *Zur Anatomie der Nieren, Abhandl. d. k. Gesell. d. Wiss.*, Göttingen, 1862, Bd. x,

layer is somewhat similarly striated, and its markings are found to be due to the same causes, the urinary tubules and the blood-vessels taking a parallel vertical course through it; but whereas they are indiscriminately disposed in the papillary portion, they are grouped into separate alternating columns which bestow a banded appearance to this portion; the associated tubules forming opaque, and the blood-vessels (*vasa recta*) light bands.

The opaque columns of the boundary layer, constituted by the uriniferous tubules, continue their course towards the peripheric capsule of the kidney. In doing so they form portions of the cortical layer termed *medullary rays*, which diminish gradually in width as they approach the capsule, and terminate altogether at a short distance from that part; thus assuming the form of slender cones, known as the *pyramids* of FERREIN. Interposed between the medullary rays are areas characterised by a *labyrinth* of convoluted tubules, which mark out the liminary region of the *Malpighian corpuscles*; and in this region the most external, and the most internal layers of the cortex respectively, form zones which are devoid of Malpighian corpuscles. In summing up the relative value of these parts in a vertical section, KLEIN* gives the following estimations:—"Taking the vertical diameter of both the cortex and medulla together as 10, the relative proportions of the above three sections, viz., cortex, boundary layer, and papillary portion are about 3·5 : 2·5 : 4." and "Taking the vertical diameter of the cortex as 7, we find a layer of the thickness of 1 next the capsule, and one of 0·8 next the boundary layer, without any Malpighian corpuscles," as shown in the diagram, p. 111, Fig. II, as *a* and *á*.

The urinary tubules commence in dilatations which embrace tufts of blood-capillaries and thereby constitute the *Malpighian corpuscles*; they thereafter take a complicated but definite course through the organ to terminate in openings on the free surface of the papillæ. In this course each tubule not only varies in situation, but with its change of shape and position, acquires differences in intimate structure, which admits of its division into several distinct portions. The diagram Fig. II, p. 111, maps out the course and relations of the renal tubules with great clearness; it is there shown that each tubule from its commencement in the Malpighian corpuscle to its termination in one of the ducts which open on the papilla, is divisible into sixteen distinct sections, which differ from one another so markedly, that they require to be individually considered.

1. The *Malpighian corpuscle* (p. 111, Fig. II, 1; Fig. III). In the early development of the embryo, the terminal portion of the uriniferous tubule becomes invaginated by the progressive growth of the *glomerulus*, which consists of a tuft of blood-capillaries. It thus happens that the membranes which enter into the structure of the renal tubule are reflected over the Malpighian tuft, which, increasing in relative size, at length gives rise to the characteristic bulbous form. When fully developed, the body thus formed consists of an outer homogeneous spherical capsule, which is an expansion of the distal free extremity of the renal tubule; its periphery is tucked in, in form of a fine sac which projects into,

* *Atlas of Histology*, London, 1880, p. 253.

and nearly fills its entire cavity. Into this sac depends the glomerulus. The *capsule of BOWMAN* thus constituted out of a hyaline *membrana propria*, is thickened externally by a greater or less proportion of a delicate fibrous tissue (LUDWIG), which, as may be expected, dips in to form an investment for the glomerulus. The inner surface of Bowman's capsule is lined by a layer of epithelial cells; in their early stages these cells are somewhat polyhedral in form; as age advances, those which line the external capsule become flattened, whilst those which cover the reflection over the glomerulus remain polygonal (see p. 111, Fig. III, *c, d*); but in the course of time these also become flattened. They all possess well marked flattened oval nuclei, and may be distinctly revealed by injecting a solution of silver nitrate through the blood-vessels, and treating them by a method to be hereafter described.

The *glomerulus* (p. 111, Fig. II, 1; Fig. III, *a*; Fig. V, *m, m*), enveloped in the invaginated capsule of the Malpighian corpuscle, takes its origin in a small afferent arteriole which branches off an interlobular artery, and enters the capsule at its inverted extremity, i.e., opposite to the neck of the tubule (p. 111, Fig. II, 2). Within this chamber it breaks up into a network of convoluted capillary blood-vessels, which are further arranged into two or more ovoid lobules, whence an emergent or efferent arteriole leaves the glomerulus by the side of the afferent vessel, and with it forms a kind of peduncle to the tuft. The lobules of the glomerulus are invested in a delicate connective tissue, continuous with a homogeneous substance which binds them together. According to AXEL KEY* this connective tissue contains somewhat flattened, branched, and nucleated corpuscles. The whole tuft is moreover enveloped in a delicate membrane composed of a single layer of nucleated endothelial plates, which dips in between the lobules HEIDENHAIN.† Between the glomerulus and the capsule of Bowman there is always an empty space, the extent of which varies with the physiological activity of the organ, and is therefore to a very large extent dependent upon the normal or abnormal state of excretion.

2°. The *neck of the Malpighian corpuscle* (p. 111, Fig. II, 2), is the constricted channel which places the space around the glomerulus in communication with the lumen of the tubule. The epithelial lining of Bowman's capsule becomes so attenuated in this section that it appears to be devoid of any lining membrane, and to consist merely of a *membrana propria* thickened on the outer side by connective tissue.

3°. The *Proximal Convoluted tubule* (p. 111, Fig. II, 3) commences as a dilatation of the neck, and increasing slightly thereafter in diameter, takes a tortuous course of considerable length within the labyrinth of the cortex to which it is confined. Its *membrana propria* is a continuation of that of the neck, and therefore of Bowman's capsule; but its lumen is reduced to about one third of its whole diameter on account of the single layer of epithelial cells which line its walls. The *membrana propria* and epithelial lining possess certain details of structure, which are com-

**Om Circulationsförhållandena i Njuarne*, Stockholm, 1865.

†*Arch. für Mikr. Anat.*, Bd. x, 1874.

mon to other parts of the renal tubules, and will therefore be considered fully in this section.

Throughout the cortical and medullary layers, the membrana propria retains a uniform aspect; at some places obscure lines, and the presence of an angular nucleus which passes towards the internal epithelium, lead us to surmise that it consisted primarily of a series of endothelial plates which have become fused together; and this conclusion is supported by analogous phenomena, which have been demonstrated in the tubes of other glands.

The epithelial cells which line the membrana propria of this section and all the other parts of the tubule with the exception of 5, 6, 12, 13, 14, 15, and 16, Fig. II, p. 111, are peculiar in the arrangement of their protoplasmic substance. HEIDENHAIN* first drew attention to this rod-like structure, which is induced more particularly at the basal attached ends of the cell, the rods appearing to run in a direction vertical to that of the tubule. In his experiments he injected sulph-indigotate of soda, and phœnicin-sulphate of sodium, into the circulation of dogs and rabbits, and found that the pigment was excreted by only those sections containing epithelium with the rod-like structure, to the elements of which he ascribed the excretory power. The rod-like structure can be best made out in sections which have been hardened in ammonium chromate solution; it can also be detected in sections which have been otherwise treated, but in the perfectly fresh organ it cannot be seen. It is evidently due to a peculiar disposition of the protoplasm which shrinks into the form described through the action of reagents; and it is probable that KLEIN† is right when he describes that structure as a honey-combed network, and says that the rods are evidently its septa seen in profile. He further showed that the pigment excreted in these regions in the kidney of a cat, into whose circulating blood an ammoniacal solution of carmine was injected, is deposited "*in the interstitial substance between the epithelial cells,*" and not in the substance of the cells themselves, as maintained by HEIDENHAIN.

In shape the epithelial cells vary. According to STRICKER, HEIDENHAIN, SPINA, and others, the gland cells of secretory organs undergo remarkable changes in colour, texture, and shape, which are dependent upon the functional activity of the cells; the cylindrical form, opacity, and turgescence of the latter, with the consequent diminution of the size of the lumen, being indicative of an active state; whilst a greater transparency, polygonal form, and large lumen point, to a passive condition of the cells. In general outlines, the cells of this section (the proximal convoluted tubule) are somewhat cubical; towards the neck they decrease very markedly in height, so as almost to appear to cease abruptly there. Throughout the tubule they vary in size, and their apposed sides are not straight, but slightly curved, the convexity of one side fitting into the concavity of that in juxtaposition with it. All the cells possess spherical centrally-situated nuclei.

* *Archiv für Mikr. Anat.*, Bd. x, 1874.

† *Atlas of Histology*, London, 1880, p. 260.

4.—*The spiral tubule of SCHACHOWA* (p. 111, Fig. II, 4), is situated in that part of the cortex known as the medullary ray, and is thereby distinguished from the proximal convoluted tubule of the labyrinth, of which it is a continuation; on reaching the boundary layer it suddenly becomes very fine, and takes a straight course through that zone as the descending limb of Henle's loop.

In the relative size and shape of its walls and lumen, it resembles the proximal convoluted tubule. Its epithelial cells, in the first part of the tubule, exhibit the rod-like structure very clearly; but this gradually dies away as the boundary layer is approached, and the cells in that locality become finely granular, with occasional exceptions in the form of a coarsely reticular structure (KLEIN). The cells at the commencement of this section are, moreover, very irregular in shape, and SCHACHOWA has pointed out that some of them are elongated columnar cells with concave sides, whilst others are broad with convex sides and convex free surfaces; thereby resembling mushrooms, and accordingly termed the *fungoid cells of SCHACHOWA*. They all possess distinct, centrally situated, spherical nuclei.

5 and 6.—*The descending limb of Henle's loop, and Henle's loop* (p. 111, Fig. II, 5, 6; Figure of H. S. Through Papillary Portion of Human Kidney, *h*). The spiral tubule of SCHACHOWA on reaching the boundary layer in the medullary ray of the cortex, suddenly narrows to form a fine straight tubule which extends through the medullary layer, and enters, for a greater or less distance, its papillary portion; the descending limb of Henle's loop thus marked out, recurves upwards to form Henle's loop; and the recurrent or ascending limb maintains its fine calibre until it reaches the boundary layer. The epithelial cells lining both of these sections become attenuated, and contain oval flattened centrally-placed nuclei. In transverse section they closely resemble capillary blood-vessels, both in size and general outlines; but they can usually be distinguished from the latter by the possession of a membrana propria, and by the greater number of their nuclei.

7.—*The ascending limb of HENLE's loop* (p. 111, Fig. II, 7), on reaching the boundary layer, gradually dilates until it reaches its maximum diameter about the middle of that zone, where its course becomes slightly wavy, and its size varies. Its epithelial cells also become modified into polyhedral forms with a basal rod-like striation; and each cell possesses a spherical strongly marked nucleus, situated towards the free extremity which projects into the lumen.

8.—*The spiral portion of the ascending limb of HENLE's loop* (p. 111, Fig. II, 8). Towards the middle of the boundary layer, the ascending limb becomes more distinctly spiral, and somewhat smaller in diameter. In minute structure its epithelial cells exhibit oval, irregular, and somewhat flattened nuclei placed towards the lumen, which is almost obliterated by the relatively large size of the polyhedral and strongly striated cells. KLEIN* notes that in the human kidney

* *Atlas of Histology*, London, 1880, p. 258.

the cells of this section contain a large amount of brownish granular pigment, and that many of them according to STEUDENER possess short somewhat imbricated processes, due to the variation in height of the cells, which are thus forced to overlap each other.

9.—*The cortical portion of the ascending limb of HENLE's loop* (p. 111, Fig. II, 9), as its name indicates, enters the substance of the cortex, and becoming narrower, straight, or slightly wavy, ascends in the medullary ray where it may become more spiral and somewhat thicker; its lumen diminishes in diameter. Its epithelial cells show the rod-like structure at their attached bases, possess flattened or angular peripheral nuclei, and have occasional imbricated processes.

10.—*The irregular tubule* (p. 111, Fig. II, 10), is a continuation of the last named segment. It leaves the medullary ray to intertwine amongst the convoluted tubules of the labyrinth, and exhibits the following peculiarities:—In outline it is altogether irregular, being wide and angular in some places, narrow and rounded in others; it owes its shape to the extreme variation in the size of its epithelial cells; its lumen being uniformly narrow. The epithelial cells naturally are imbricated, and they display the rod-like structure more markedly than in any other portion of the renal tubule. Each cell contains an oval or angular nucleus towards its periphery.

11.—*The intercalated section of Schweigger-Seidel** (p. 111, Fig. II, 11). This portion is known also as the *distal convoluted tubule*. It agrees in location and structure with the proximal convoluted tubule.

12.—*The curved segment of the collecting tube* (p. 111, Fig. II, 12), is a narrow continuation of the distal convoluted tubule, which passes through the labyrinth to join the next:—

13.—*The straight section of the collecting tube* (p. 111, Fig. II, 13) which is situated in the medullary ray, agrees with the last named segment in its narrow diameter, and small but distinct lumen with its single layer of homogeneous cells, which may vary in shape from regular polyhedral to flattened and even spindle-shaped elements. They all possess well marked spherical or ovoid nuclei, and may show imbricated processes.

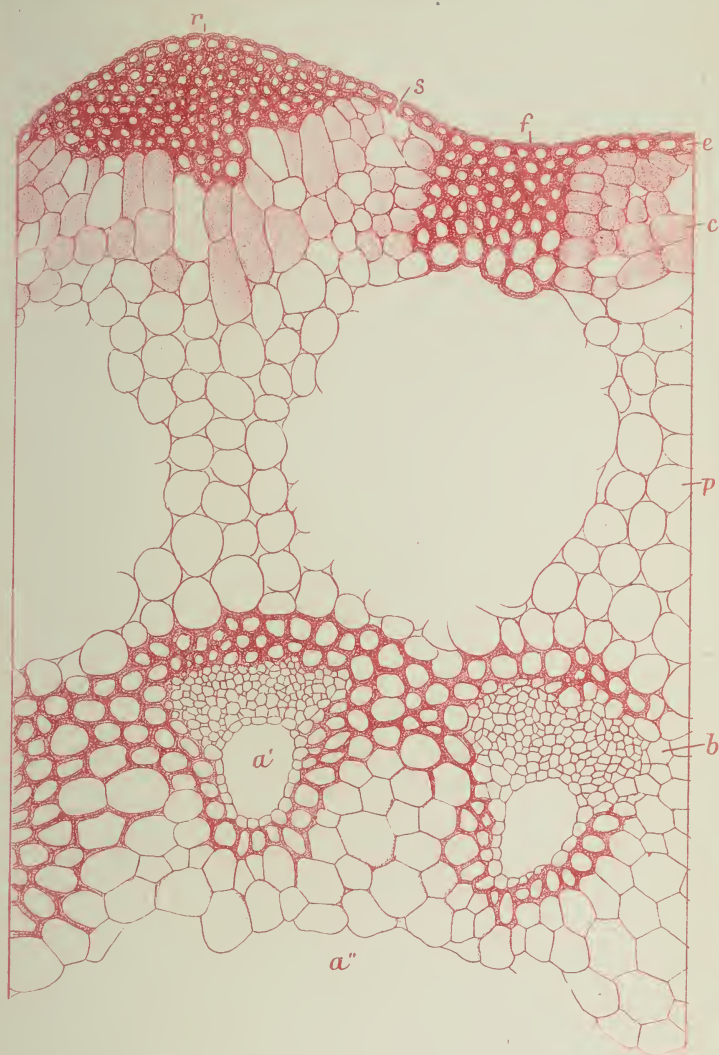
14.—*The collecting tube of the boundary layer* (p. 111, Fig. II, 14) is a continuation of that in the medullary ray; its diameter is greater and its lumen larger. Its epithelial cells are short columnar, and closely resemble in other respects those of the foregoing section.

15 and 16.—*The collecting tubes and ducts of the papillary portion* (p. 111, Fig. II, 15, 16, Figure of H. S. Papillary portion of the Human Kidney, l, s), are but enlarged copies of sections 13 and 14; the size of their lumen and its epithelial cells, depends upon the diameter of the tube, which increases by accessions of other ducts, until it forms the short large *duct of BELLINI* which open on the papilla.

* *Die Nieren des Menschen*, Halle, 1865.

KLEIN* has described a delicate structure which lies closely adherent to the surface of the epithelial cells in the lumen of all the sections of the renal tubules in the dog, with the exception of the descending limb of Henle's loop and the loop itself. To this he has applied the name *centro-tubular membrane*, and asserts that every here and there it possesses an oblong nucleus more or less wedged in between the epithelial cells. In the convoluted tubules and the spiral tubule, these nuclei are scarce, but in the ascending limb of Henle's loop, sections 8, 9, 10, and 12 in Fig. II. p. 111, their number is augmented, and may be considerable; the nuclei moreover appear to be placed in depressions in the epithelium. In all the nuclei of the epithelial cells, KLEIN has detected a limiting membrane; and has unequivocally demonstrated the presence of an intranuclear net work, especially in the cells from the human subject.

* *Atlas of Histology*, London, 1880, pp. 260—1.



del. ad nat.

West, Newman & Co. lith.

EQUISETUM ARVENSE.

T.S. of Stem.

x 100

THE FIELD HORSE-TAIL.

(EQUISETUM ARVENSE).

T.S. of Aerial Stem, Stained Carmine.

× 100 diameters.

r. Ridge, *f.* Furrow, *e.* Epidermis, *s.* Stoma, *c.* Cortical Parenchyma with Chlorophyll bearing Cells, *p.* General Parenchyma, *a.* Cortical Air Cavity, *a'.* Air Cavity of Vascular System, *a''.* Central Air Cavity, *b.* Vascular Bundle Sheath.

Etymology.—FIELD (fēld), *n.* [A-S., O. Sax., and Ger. *feld*, M. H. Ger. *velt*, D. *veld*, Sw. *fält*, Dan. *feldt*.] A wide extent of cleared land, or felled ground, suitable for pasturage or cultivation.

HORSE-TAIL, *n.*, from HÔRSE, *n.* [A-S. *hors*, for *hros*, O. Sax., Icel.; and O. H. Ger. *hros*, N. H. Ger. *ross*, M. H. Ger. and D. *ros*; whence Pr. *ros*, O. Fr. *rous*, a horse, Pr. *rossa*, Fr. *rosse*, It. *rozza*, a sorry horse, jade. Cf. Skr. *hrêsh*, to neigh]. A hoofed quadruped of the genus *Equus*; and TAIL, *n.* [A-S., *tægel*, *tægl*, Icel. *tagl*, L. Ger. and Sw. *tagel*, O. H. Ger. *zagil*, *zagal*, M. H. Ger. and O. Ger. *zagal*, from Goth. *tagl*, hair]. Any long flexible terminal appendage.

EQ'UI-SĒ'TUM, *n.*; *pl.* EQ'UI-SĒ'TA. [Lat., from *equus*, horse, and *seta*, a thick, stiff hair, bristle]. (*Botany*). A genus of cryptogamic plants belonging to the class *Equisetaceæ*. ARVEN'SE, [Lat. *arvum*, field].

DESCRIPTION.

The plants which are grouped together under the class *Equisetaceæ*, are so very much alike, that they constitute but one genus, *Equisetum*. In affinities they closely resemble the *Filices* in their mode of reproduction; and in the structure of their vegetative organs are most nearly allied to the extinct *Calamites*, whilst they approach, to a less extent, in form of tissues, the Australian dicotyledonous *Casuarinææ*.

Equisetum arvense, the field, or cornfield, horsetail, is the commonest form met with in Great Britain. It may be found during the warmer periods of the year growing in abundance on roadsides, banks, and fields; and ascends to nearly 2,000 ft. in the North of England. It is further distributed over the whole of Europe, N. Africa, N. Asia, Himalaya, and N. America (HOOKER*).

In common with the other species, it possesses a perennial underground jointed stem or *rhizome*, which creeps at a depth of from 2—4 ft., and in some species extends over an area of from 10—50 feet in dia-

* *The Student's Flora of the British Islands*, 2nd Ed., London, 1878, p. 500.

meter, and more (SACHS*). The rhizome of *Equisetum* varies in diameter from 1 — 2 lines — $\frac{1}{2}$ in. or more in diameter, and flourishes best in a damp, gravelly, or loamy soil. At its nodes it produces a number of adventitious roots, and the internodes of some (*E. Telmateia*, *E. sylvaticum*) are covered with a feltwork of brownish root-hairs, like those which invest the rhizome of ferns. In *E. limosum* and *E. palustre* the rhizome is glabrous, whilst in others it is dull, yet smooth; in all the species the fluted internodes of the aerial axes, which will hereinafter be noted, are absent or only faintly indicated in the underground system. A transverse section through an internode of that system shows that it is sometimes devoid of a central air cavity; but it is found that the lacunar system of the cortex and fibro-vascular bundles is invariably present. Provision is thus made for the supply of air to the tissues of the rhizome during the vegetative period, which could not otherwise be effected through the very compact soil in which it grows.

The material which has been assimilated through the aerial system is stored up in the rhizome, when the vegetative period of the former (which is usually confined to one term of life, and is only rarely prolonged through a course of seasons or years) has ceased; and endows every part of the latter, and the underground nodes of the ascending system, with the power to produce new stems. Very often the internodes preceding the terminal buds of the rhizome become greatly thickened and store up quantities of food-materials; they sometimes take on the characters of ovoid tubers (*E. arvense*), and these may increase by budding, and give rise to a moniliform series; more rarely these tubers obtain at the middle of the rhizome, and under exceptional circumstances may produce new stems; their parenchymatous cells are usually full of starch granules.

Thus it is, that when the colder period of the year comes round, and the aerial system has faded away, the underground root-stock retains its vitality; which it evidences towards the advancing spring by the development of numerous buds, destined to form its aerial system, the system which consists of assimilative and reproductive members.

Under the favourable conditions of warmth and moisture which are brought about by the advancing summer, the already developed ascending axes merely elongate and unfold to produce the green vegetative organs. Their habit is thereafter determined by the number and length of the verticillate or whorled system of slender lateral shoots which they produce; in some these are absent (*E. hyemale*); in others, they are scarce (*E. palustre*, *E. limosum*); whilst in the third group (*E. arvense*, *E. sylvaticum*, *E. Telmateia*) they are abundantly manifested. In all they are developed from buds which arise in the cortex of the stem, upon which the leaves are peculiarly arranged in form of toothed sheaths, the result of a coalescence of their bases. The stem, moreover, is furrowed, and may be simple or branched; the furrows and their corresponding ridges are due to the linear arrangement of the cells and vessels which constitute its substance. It sometimes attains gigantic proportions, as in *E. giganteum* of S. America, which reaches the height of about 26 feet, although its diameter is comparatively slender (about half an inch), and there-

* *Text-Book of Botany*, English translation, Oxford, 1875.

fore requires the support of neighbouring plants to enable it to maintain its upright position. Geological evidences, however, show that the *Equisetaceæ* (*Calamites*) of bygone ages were even more stupendous, and often attained a girth of as much as 3 feet. But, as a rule, the existing forms are relatively diminutive; rarely exceeding 5 feet in height, and $\frac{1}{2}$ inch in diameter. The barren stems of *E. arvense* scarcely ever grow higher than $2\frac{1}{2}$ feet; its fertile axes barely 10 inches. HOOKER* describes it thus:—"E. ARVEN'SE, L.; barren stems 6—19—grooved, branches spreading, sheaths of fruiting stems distant loose with teeth ribbed to the tip."

"Roadsides, banks and fields; ascends to nearly 2,000 feet in the N. of England; frt. April.—Barren stems erect or decumbent, slightly scabrid, usually ending in a long naked point; branches crowded, erecto-patent, 4-gonous; fertile stems (rarely with branches) stouter, shorter; sheaths scarious."

During the summer months, whilst the sterile erect stems are flourishing, their underground internodes develop buds which are destined for the sexual generation of the individual. These buds remain in an apparently dormant condition during the winter, and only commence their vegetative activity with the coming spring. Their subterranean existence, however, is spent in a gradual growth which may even culminate in the formation of the sporangiferous spikes, which require but the influence of spring to set up a rapid ascending growth. The fertile axes thus produced vary somewhat in the different species; in all, they are at first of a brownish-yellow colour, and destitute of chlorophyll. In *E. arvense* and *E. Telmateia* they rapidly elongate, and on the maturation and dissemination of their spores, decay; in *E. sylvaticum* and *E. pratense*, the terminal spike when ripe is thrown off, and the axis assumes the form and functions of an assimilative sterile member; in yet other species, no special fertile axes are produced; the sporangiferous spikes appearing indiscriminately at the summits of the vegetative stems, which thus act both as organs of assimilation and reproduction. *E. limosum* differs slightly from *E. arvense* in the development of its reproductive elements, which grow *pari passu* with the extra terrestrial elongation of of its fertile axis.

The underground activity of the plant is thus in reality the most important part of its life history. The formation and division of its cells take place both in the sterile, and in nearly all the parts of its fertile members, in this situation; their aerial existence being manifested chiefly in the rapid elongation of the cells which have already been formed; although entirely new cell formations do sometimes obtain, more particularly at the basal ends of the internodes which are enveloped in the leaf sheath. The cells of this part often continue young for a considerable period during the growth of the plant.

THE MICROSCOPIC CHARACTERS OF THE STEM IN *EQUISETUM ARVENSE*.—A transverse section examined under a low power (about 25 diameters), is sufficient to display the general disposition of the systems of tissue. Thus viewed, the aerial stem is seen to have a stellate outline which is due to the development of its ridges and furrows. The central portion of the stem is occupied by a large air space, the *central air cavity a'*, which is

* *Loc. cit.*

surrounded by a number of fibro-vascular bundles, each of which contains an air space *a*, the *carinal canal*, so called because the bundles lie immediately below the external ridges. The zone of fibro-vascular bundles underlies the layer of cortical parenchyma which is likewise interrupted by numerous air spaces *a*, termed the *vallecular canals*, which are placed immediately below the furrows of the epidermal system which bounds the whole externally. In the rhizome the central canal is often deficient, being filled by the cells of the fundamental tissue; and the root consists of a central axis of vascular bundles surrounded by a parenchyma, and destitute of lacunæ such as abound in the stem. The forms of the cellular elements which build up the structures just briefly noted, require a power of about 100 diameters for their elucidation. It may then be seen that the tissues admit of a threefold division.

1.° *The Epidermal system*.—The epidermis is composed of a single layer of cells. In transverse section these cells present oblong outlines and thickened walls; those over the ridges are somewhat narrower than those which bound the furrows; and amongst the latter only, are stomata to be found. Their external liminary walls coalesce to form a cuticular layer which is strongly silicified, and presents at intervals small rounded prominences which project outwardly. The presence of stomata, where they do not happen to have been cut exactly through the centre, may always be detected by the peculiar-guard cells which bound their openings, and which exhibit fine silicified radii which run at right angles to the apertures.

If a portion of the epidermis be stripped off a fresh stem and examined, it will be seen that the outlines of its cells are sinuous, and that in form they are somewhat elongated and oblong; those over the ridges exceeding in length the cells of the furrows, between which the stomata may be recognised in irregular longitudinal rows.

Each stoma is bounded by four guard cells, the inner of which is overlapped by the outer pair. STRASBURGER* accounts for their position in the following manner:—the four cells arise through the division of a single epidermal cell, and at first lie side by side on the same level; the innermost pair which bound the stoma cease to develop, are passed inwards, and thus overreached by the outer pair, which grow more rapidly.

The rhizome, roots, and sterile and fertile colourless axes, are devoid of stomata; and in the rhizome the epidermal cells are brownish and develop delicate root hairs.

Beneath the epidermis longitudinal bundles of thick walled *hypodermal cells* occur; they are colourless, and greatly elongated, with transverse or oblique septa. In transverse section they form isolated lozenge-shaped bundles under the ridges, and somewhat rectangular systems in the middle of the furrows; these last extend as far inwards as the cortical air spaces *a'*; and it is only between these two systems that a small region occurs where the cortical parenchyma *c*, is bounded by a single layer of epidermal cells, the area to which the stomata are confined.

* *Beitr. zur Entwicklungsges. d. Spaltöffnungen*, Pringsheim's Jahrb., Bd. v.

2°. THE CORTICAL SYSTEM, underlies the hypodermis, and only comes into contact with the epidermis where the stomata place it in communication with the exterior. Its cells are arranged in two ways:—1°. There is a layer of chlorophyll bearing elements which form a loose network of thin-walled parenchyma, the cells of which are radially disposed in bands of from one to three cells deep. This layer merges into a thin-walled parenchyma of somewhat regular hexagonal cells, which we shall term the *interlacunar cortex*, devoid of chlorophyll, and bounding the *vallecular lacunae* (a) on each side.

Only a mere remnant of the fundamental tissue remains, and shows signs of having been ruptured and dissipated at the margins of the central canal (a'').

3°. *The Fibro-Vascular System*.—Immediately below the interlacunar cortex, comes a single layer of thick-walled parenchymatous cells, which forms a ring surrounding the whole of the fibro-vascular bundles; this is the *vascular bundle sheath* (b).

The fibro-vascular bundles form separate closed systems arranged in a circle, each one underlying a ridge of the surface. The bundles run parallel to each other in the internodes; in the nodes they form annular coils produced by the coalescence of the bundles of the stem and those of the leaf sheath. Each bundle is traversed by an air space, the *carinal canal* (a'), which lies on the inner side of the bundle and arises through the degeneration of the first formed annular, reticular, or spiral vessels and their intervening thin-walled cells. On each side of this lie a few reticular and annular vessels; and externally, between it and the bundle sheath, the phloëm portion is situated; the whole bundle being surrounded by a layer of prosenchymatous cells. The phloëm consists of thin-walled cambiform cells, and a few large sieve-tubes which correspond to the soft bast and lie nearest to the carinal air canal; whilst externally to this a few thick-walled narrow hard-bast-like cells obtain immediately beneath the thicker-walled cells which surround the whole bundle, and which gradually pass into a thin-walled parenchymatous tissue the remnant of the fundamental tissue.

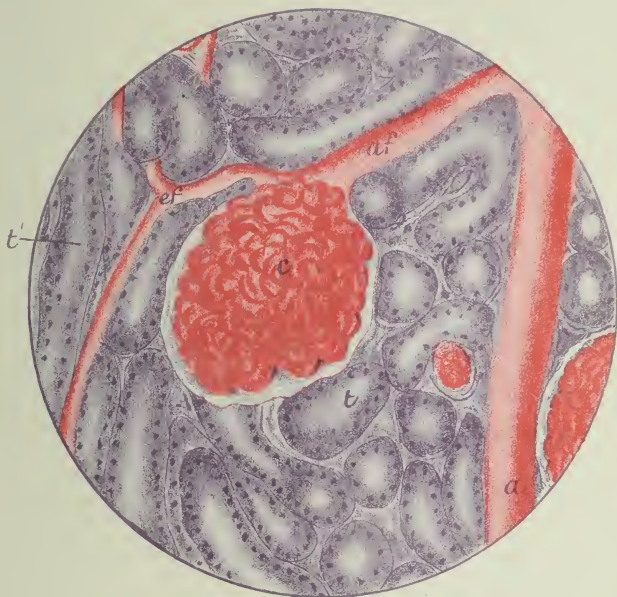
METHODS OF PREPARATION.

See this Journal pp. 14—16, 40.

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del. et nat.

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V. S. HUMAN KIDNEY.

Showing part of the labyrinth and medullary ray.

X 145

THE KIDNEY.

V. S. Human Kidney.

Injected Carmine, and Stained Logwood.
× 145 diameters.

a. Interlobular artery, *af.* Afferent arteriole, *ef.* Efferent vessel, *c.* Capillaries of glomerulus, *t.* Sections of convoluted tubules of labyrinth, *l.* Sections of tubules of medullary ray.

Etymology.—KID'NEY, *n.*; *pl.* KID'NEYS. See p. 109.

DESCRIPTION.

THE BLOOD-VASCULAR SYSTEM OF THE HUMAN KIDNEY.—In Figs. IV. and V, p. 111, two drawings are given, showing the distribution of blood-vessels within the substance of the Kidney. Fig. IV, copied from LUDWIG's* diagram, represents clearly the course of the vessels within the medulla and cortex. Fig. V, is a drawing taken from BOWMAN,† to show the disposition of the capillaries within the Malpighian corpusele; the relations which these tufts of blood-vessels bear to the surrounding and enveloping structures, are fully explained above.‡ In the accompanying plate to this paper, a drawing taken from the cortical region of the human kidney, which had been injected with a carmine mass and stained with logwood, is given, not so much as a means of conveying an idea of the general distribution of the blood-vessels and their relation to the substance of the kidney, as an exact representation of what may be seen in an ordinary preparation. The judicious combination of a large number of such drawings can alone supply the information required in the study of so complex a structure; its value, therefore, lies in the fact that it portrays and localises certain elements, which may always be recognised by careful observation.

A rough dissection of the kidney shows that it receives its blood chiefly by means of the renal artery, which is comparatively large in proportion to the size of the organ which it supplies. This, however, is not its only vascular source; for if the renal artery be tied, the kidneys may be partially injected from the aorta, by means of branches of the lumbar arteries, which are associated with its capsular and extra renal blood

**Art. Kidney, Stricker's Human and Comparative Histology, New-Syd. Soc. Transl.*, Vol. ii, 1872, pp. 83-109.

†*Phil. Trans. Roy. Soc.*, London, 1842.

‡See this Journal, pp. 121-122.

supply (LUDWIG). The renal artery divides into four or five primary branches, which enter the hilus between the renal vein and ureter, and may thereafter be seen in the sinus to pass in amongst the infundibula, where they are generally surrounded by a large proportion of adipose tissue. The arteries now divide and sub-divide to enter between the Malpighian pyramids; they are surrounded by longitudinal and circular bands of muscular fibres, and by a delicate connective tissue which accompanies them in their course through the papillary portion. On reaching the boundary layer they are associated together in longitudinal groups which open into incomplete arches, between the cortex and medulla, from which smaller *interlobular arteries* (Fig. IV, *ai*, Fig. V, *a*, p. 111; and drawing of injected and stained kidney, *a*), are given off. These interlobular branches ascend towards the periphery of the cortex, and in doing so give off short transverse branches, one of which is distributed to each Malpighian corpuscle, as its *afferent arteriole* (Fig. V, p. 111, *af*; and drawing of injected and stained kidney, *af*), which breaks up thereafter into a tuft of capillaries in a manner already described. Occasionally the afferent arterioles give off lateral branches before they enter the glomerulus, which ramify over the convoluted tubules in their neighbourhood. On reaching the portion of the cortex which is devoid of Malpighian corpuscles, the interlobular arteries either cease by ending finally as afferent arterioles to those structures; or they may continue towards the capsule, and supply, by a meshwork of capillaries, the convoluted tubules which exist in that region, and may even penetrate the capsule itself, and form part of its capillary system.

The larger arterial arches which subsist between the cortex and medulla, moreover, give rise to a system of vessels which enter the boundary layer and divide into more or less parallel groups which descend towards the papillary portion between the renal tubules, and are continuations of the medullary rays; they thus bestow the peculiar banded appearance to that layer, caused by the so-called *arteriolæ rectæ* (Fig. IV, p. 111, *ar*), whose capillaries form a network with those of the cortical layer, and in descending through the medulla, gradually decrease in number through lateral branches, which they give off to the adjacent tubules, where they form an elongated network. Around the mouths of the ducts they give rise to a close meshwork of capillaries (Fig. IV, p. 111, *vp*).

The *efferent vessel* of the Malpighian corpuscle (Fig. V, p. 111, and drawing of injected and stained kidney, *ef*) breaks up into a dense capillary network of veins which ramify throughout the cortex, supplying all its tubules. The meshes of the labyrinth and periphery are smaller and more regular than those which obtain in the medullary rays, which become elongated (See Fig. IV, p. 111). The capillaries of the periphery of the cortex open into minute veinlets, which in their turn empty into larger vessels like so many rays; these larger vessels are hence termed *Venæ Stellatæ*, or *Stellulæ* (VERHEYEN). Each vena stellata thereafter passes into the labyrinth to become an *interlobular vein* (See Fig. IV, p. 111), and in its passage downwards, receives accessions from the capillary network which supplies the regions around. It accompanies the interlobular artery, and finally terminates at the base of the cortex in one of the larger venous arches situated between the cortex and medulla. From this,

venæ rectæ are given off, which, in their mode of arrangement, closely resemble the *arteriæ rectæ*; they vary very considerably in their passage through the medulla, and terminate finally in single trunks at the beginning of the *papillæ*.

THE LYMPHATIC SYSTEM of the kidney, so far as it has been worked out, is manifested in form of a plexus in the capsule, from which free intercommunications place it in connection with lymph spaces which subsist around the convoluted tubules of the cortex. A plexus of vessels also obtains around the larger blood-vessels which enter the medulla; and, according to LUDWIG and ZAWARYKIN, there is a system of intertubular lymph spaces throughout the organ by means of which the deeper lymphatics communicate freely with the superficial capsular system.

THE NERVES of the kidney are derived from the renal plexus, and the lesser splanchnic nerve; they pass directly into the organ along with the blood-vessels, and may be traced as far as their finer ramifications between the medulla and cortex. Their ultimate distribution yet remains to be investigated.

METHODS OF PREPARATION.

EXAMINATION OF THE FRESH KIDNEY.—Procure a fresh kidney with its attached capsule. Slice it into two equal longitudinal halves. The appearances indicated in Fig. I, p. 111, may be easily observed. For the study of the fresh epithelial cells, use a sheep's or a rabbit's kidney from a newly killed animal; make sections with a VALENTIN'S knife, or in the freezing microtome, and examine in a $\frac{3}{4}$ per cent. solution of sodium chloride, or the kidney may merely be scraped, both from the cortex and medulla, and the scraping examined in normal saline solution. The epithelium of the convoluted tubules will appear cloudy, that of the medullary tubules clearer. The basement membrane may also be seen in form of fine homogeneous, sometimes folded, bands. The addition of dilute acetic acid will render the tissues clear, and reveal the nuclei of their cells. Portions of fresh kidney are not suitable for permanent preparations.

LUDWIG'S METHOD OF ISOLATING THE RENAL TUBULES.—Into a flask containing one part of pure hydrochloric acid to four parts of rectified spirit, place a few vertical sections of a fresh kidney. Stopper the flask with a cork, through which a long glass tube is made to pass into the liquid; boil over a sandbath for from one to three hours; replace the mixture with distilled water, and allow the sections to soak for about twenty-four hours. The tubules may then be readily isolated by shaking a section in a test tube with water. Thus obtained, they may be mounted, stained, or unstained, in Farrants's liquid.

INJECTING THE KIDNEY WITH NITRATE OF SILVER is the best method for demonstrating the epithelial lining of the Malpighian corpuscles. The kidney ought to be perfectly fresh and injected *in situ*. For this purpose a rabbit should be killed by bleeding, either by severing the arteries of the neck, or by cutting through the femoral artery whilst

the animal is under the influence of chloroform. A median incision may now be made from the xiphoid cartilage towards the anus; and the abdominal viscera thus laid bare should be gently deflected to expose the kidneys in their natural position. The injection should be made through the renal artery (which may easily be detected as an empty vessel running towards the hilus of the kidney) by means of a large hypodermic syringe, with a half per cent. solution of silver nitrate. The organ will become distended and exhibit an external whitish appearance, when the artery and vein may be ligatured, and the whole removed from the body. Sections should be taken with a VALENTIN'S knife, as freezing is apt to destroy the delicate epithelium by puckering it up. The sections thus obtained must next be exposed to diffuse daylight in distilled water or spirit, for a variable length of time, until they assume a brownish appearance; they may then be removed to spirit, from thence to oil of cloves, and mounted in Canada balsam or dammar solution. The silver nitrate penetrates through the glomerulus and stains the interstitial substance of the epithelial cells, and they are thereby distinctly mapped out from one another.

INJECTION OF THE KIDNEY WITH A GELATINE MASS coloured with carmine or blue, is also best effected *in situ*, to prevent too large an escape; because of the anastomoses which obtain between the renal and lumbar arterial systems. The animal should be kept in a warm bath at a temperature of about 40° C., and the canula of the injecting apparatus inserted into the renal artery close to the aorta. As soon as the mass flows freely from the renal vein, it should be ligatured, and the vessels allowed to fill gradually; after which the artery may be tied, the organ removed, and plunged into methylated spirit. It should be allowed to remain in this for a day, and may then be cut into pieces, and the hardening completed in spirit. Sections may be cut at the end of a fortnight, and mounted stained or unstained in any of the ordinary media.

HARDENING THE KIDNEY may be accomplished by any of the three following methods:—

(i). CHROMIC ACID AND SPIRIT MIXTURE, See pp. 40, 70.—Pieces cut transversely and longitudinally should be treated in a manner precisely similar to that used for the liver (p. 85).

(ii). *Muller's fluid*, See p. 71. Three weeks suffices for the kidney.

(iii). *Ammonium Chromate* is recommended by HEIDENHAIN as a peculiarly useful reagent for hardening the kidney in order to exhibit the basal rod-like structure of the epithelium of its tubules detailed at p. 123. A five per cent. solution in distilled water should be used, and the pieces allowed to remain in it for about two days; they must then be thoroughly well washed to remove all traces of colour, and the hardening completed in 50 per cent. alcohol gradually increased to absolute alcohol, after which sections may be cut and mounted in the usual way.

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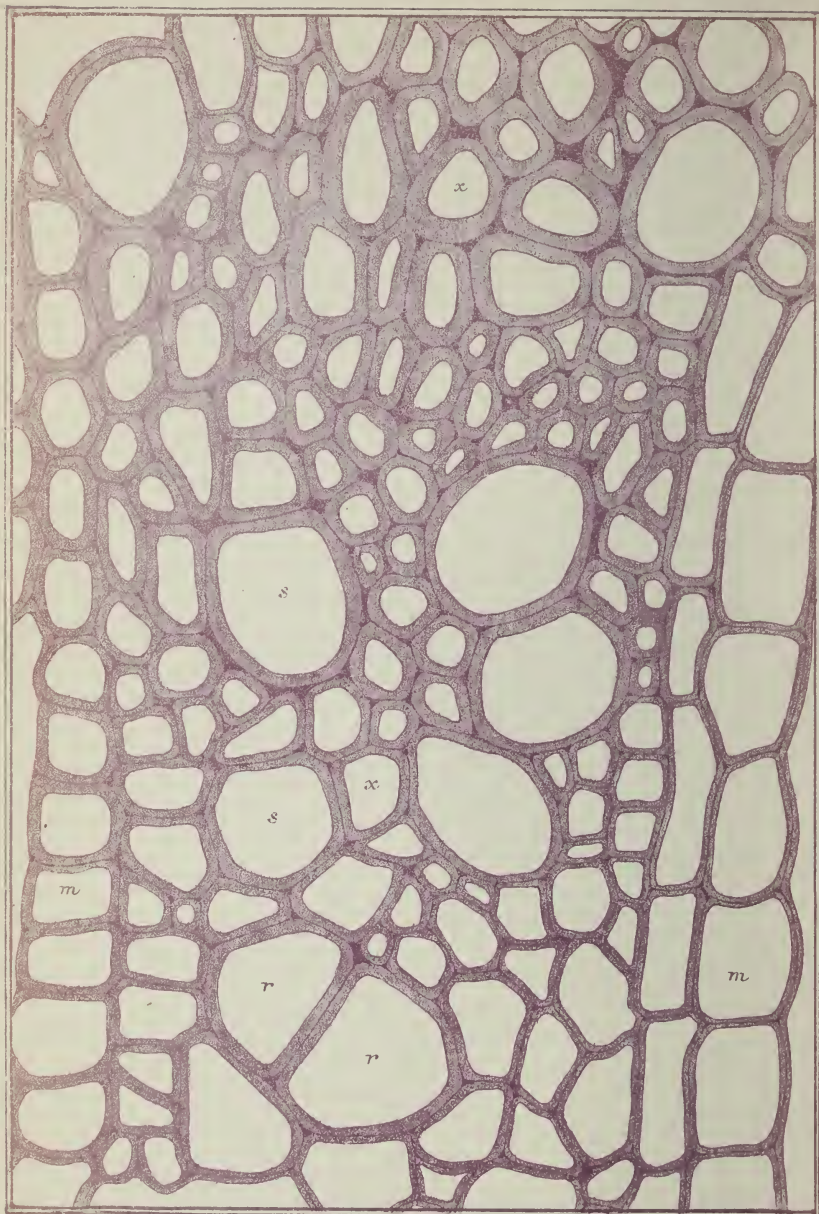
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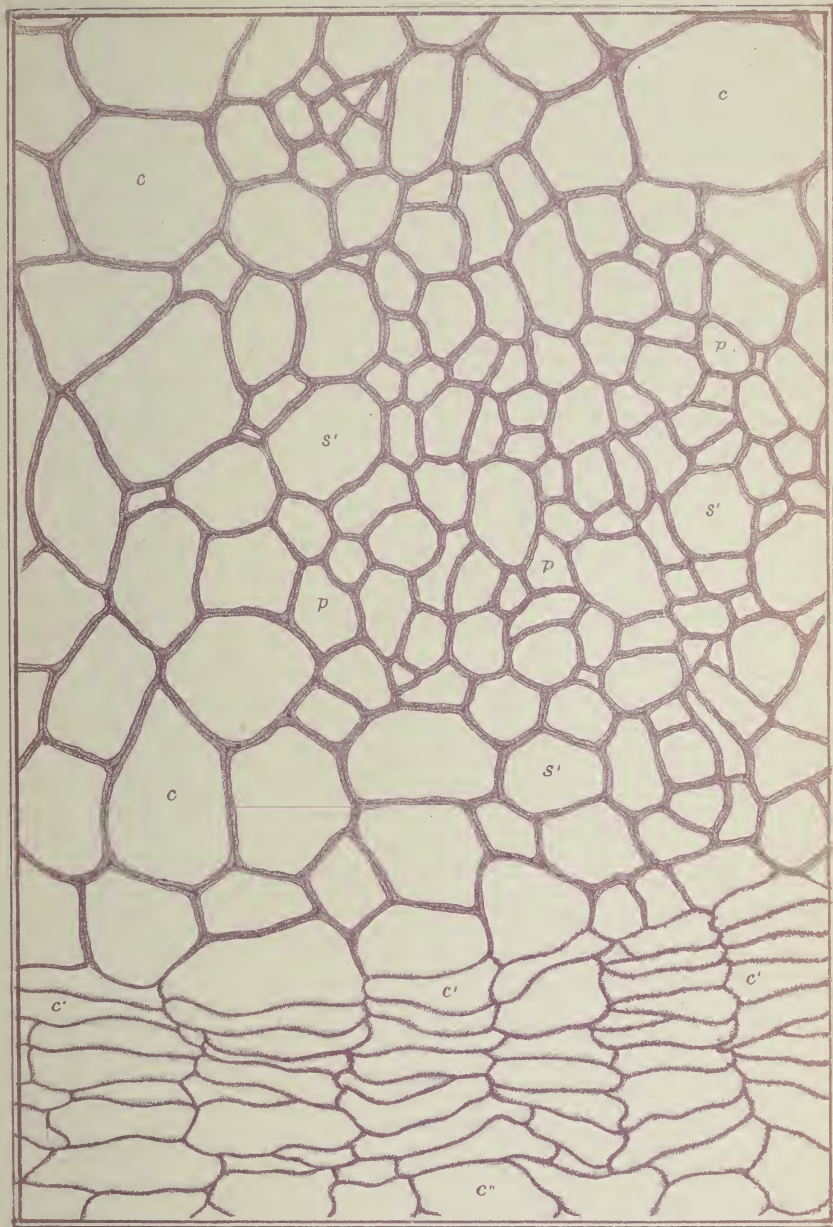




Æ. de. ad nat.

Portion of Xylem.

T. S.
Taraxac



West, Newman & Co. imp.

Portion of Bast and Cambium.

T. S. OF A ROOT.

DANDELION.

(LEONTODON TARAXACUM. L.)

Stained Logwood.

× 700 diameters.

c Cells of the Cortex ; c'. Cambium Cells ; c''. Passage of Cambium into Xylem Portion ; s. Spiral Vessel ; s'. Sieve Tube ; p. Parenchyma of Phloëm ; r. Reticulated Vessel ; x. Wood Parenchyma ; m. Parenchyma of Medullary Radial System, in the neighbourhood of which laticiferous elements usually obtain.

Etymology.—Root, *n.* [Icel., Fries., and Sw. *rót*, Dan. *rod*, allied to Lat. *radix*, Gr. *ρίζα*, root]. (*Botany*) That part of the plant which usually descends into the soil, fixing it, and absorbing therefrom certain nutritive matters. Its growing point is always protected by a layer of cells, the root-cap (*pileorhiza*); it never develops leaf-buds, and only occasionally buds of any sort, and is generally devoid of chlorophyll.

DĀN'DE-LĪ'ON, *n.* [From Fr. *dent de lion*, lion's tooth, because of the size and shape of its toothed runcinate leaves]. (*Botany*) A perennial herbaceous plant of the order COMPOSITÆ, and genus *Leontodon* (Gr. *λέων* and *ὀδούς*) of LINNÆUS, and *Tarax'acum* (Gr. *ταράσσω*, from its *alterative* properties) of other taxonomists. SYNONYMS, *Taraxacum officinale*, *Taraxacum dens-leonis*.

DESCRIPTION.

The primary fusiform root of the *Dandelion* has been chosen as illustrative of the general intimate structure of the root, on account of the well-defined forms of tissue which it presents. The most important parts of these tissues have been figured under a magnifying power of 700 diameters. The cells of the phloëm portion are shown to be composed of thin walled parenchymatous elements, amongst which are interspersed numerous sieve-tubes, whose larger transverse diameter at once localises them ; surrounding the group of cells, which thus constitute the soft bast, except at its inner aspect, come thicker-walled and much larger parenchymatous cells, the cortical cells. At the base, or inner portion, the phloëm is seen to pass, by a tolerably distinct line of demarkation, into a layer of cells with elongated oblong outlines in transverse section, these represent the *cambium layer*, or *secondary meristem*, whereby the root is enabled to increase in thickness in the same manner as the stem, adding to the soft bast which lies external to it, and to the xylem which underlies it. In its passage towards the xylem portion the cambium cells may be observed to grow wider ; their walls, however, retain the characteristic tenuity for which they are remarkable, until they merge gradually into the xylem itself.

The second picture represents a portion of the xylem towards its central aspect. It is seen to be composed of numerous thick-walled cells, some of which, the reticulated and spiral vessels, are of relatively large size. These last are closely packed in amongst numerous smaller cells, the wood parenchyma; and the group thus formed is bounded on each side by rows of radially disposed cells, which mark out the medullary system, and are thinner-walled and parenchymatous. At irregular intervals, chiefly in the last mentioned region, laticiferous vessels may be detected by their contents, which, even when subjected to staining reagents, may be recognised by their high refractive indices.

So far, we have considered the general appearances and the significance of the elements, isolated portions of which have been figured; we now pass on to the description of the structure of the root, from which the relative value of the parts which have already been noted, may be gathered.

The definition of the root given above holds good for the majority of plants; but there are numerous exceptions, of which the following are the most important:—

Plants which are destitute of a system of fibro-vascular bundles do not possess roots, although structures are produced, which, in fulfilling the functions, and assuming the habit of the root, almost deserve to have that title bestowed upon them; as in the *Fucaceæ* amongst the *Algæ*, and even in some of the lower unicellular forms, as *Vaucheria* and *Caulerpa*. On the other hand, although vascular plants usually possess roots, there are several single instances amongst them in which those structures do not obtain; thus *Salvinia* amongst the *Rhizocarpeæ*, the lycopodiaceous genus *Psilotum*,* the orchids *Corallorrhiza innata* and *Epipogium Gmelini*, *Utricularia* also, and *Lemna arrhiza* (which, however, does not possess fibro-vascular bundles) are all devoid of roots.

Roots are usually buried in the soil, but this is by no means a constant phenomenon amongst plants. The Indian Banyan tree (*Ficus Indica*) produces numerous aerial roots from its stem or branches, and these may continue to depend in the air, or finally penetrate the soil in form of so many props. Similar instances are to be found in the Mangrove (*Rhizophora Mangle*) of the American swamps, the *Pandanaceæ* and *Aroideæ*.

Amongst epiphytes (aerial orchids, etc.), the roots merely serve to attach the plant to external objects, such as other plants, etc., they do not live parasitically on their hosts.

The Ivy (*Helix hedera*), and *Ficus repens*, afford well-known examples of adventitious roots which enable them to cling for support to stable structures. The floating primary root of *Trapa natans* is peculiar in that it ascends instead of descending.

Yet further exceptions are to be met with, especially amongst aquatic plants. Everyone is familiar with the manner in which the roots of the common duckweed, *Lemna*, merely depend into the water, and never

* NÄGELI and LEITGEB have shown that the apparent roots of *Psilotum triquetrum* are only underground shoots, which, although they possess the structure, and exhibit the functions of true roots, nevertheless become ordinary leafy axes when they emerge above ground, never possess a root cap, and when carefully examined show signs of leaf traces.

become fixed in the soil ; and the same observation may be made with regard to the water crowfoot (*Ranunculus circinatus*).

Beside all these, comes the interesting group of parasitic epiphytes, which derive nourishment at the expense of their hosts. Foremost amongst them we may mention the mistletoe (*Viscum album*), whose germinating root penetrates the tissues of its host, and may there cause knotty growths, and imbibes the nutritive elements of its victim to such an extent as to prove fatal to its existence ; it does not, however, depend entirely upon its host through its roots, for it produces green branches and leaves which assist in its assimilative processes. The toothwort (*Lathræa squamaria*), and the broom-rape (*Orobanche*) family, go a step further, in depending entirely upon their parasitic habit. The various species of dodder (*Cuscuta*), instead of germinating as parasites, take root in the soil in the ordinary way ; but after their stems are developed, they become established on other plants ; their aerial roots take on the form of sucking discs which become fixed on the tissues of their host, and draw from them the nutriment which their first roots now cease to gather from the soil. Lastly, there are plants which usually produce both parasitic and ordinary roots ; such are *Thesium linophyllum* and other species of bastard toadflax, which victimise the roots of other plants. Roots which are attached to tissues of their hosts, and live on their sap are termed *haustoria*.

Chlorophyll is usually absent from roots, and as one would expect stomata do not occur except in rare cases. The roots of *Menyanthes trifoliata* possess chlorophyll, and the green aerial roots of many epiphytic orchids exhibit stomata.

The two distinguishing characters which identify the root from the stem, are, its possession of a root-cap at some period of its growth, and its incapability of producing leaf-buds. The development of roots also takes place deep down, and breaks through the layers of tissue which overlie them ; they are thus endogenous in growth, and thereby differ from leaves and stems which grow exogenously.

There are, however, transitional forms where the root takes on the characters of the stem. HOFMEISTER, REICHENBACH, and others, have noted that the older lateral roots of *Neottia nidus-avis* throw off their root caps and produce leaves beneath their apices, and the converse statement is made by METTENIUS with regard to many *Hymenophyllaceæ*. NÄGELI and LEITGEB have further pointed out, that amongst the *Selaginellæ*, leafless shoots are produced which do not develop root-caps until they reach the ground.

The root commences to develop in the young embryo which is produced from the fertilised ovule, with rare exceptions (*Orchideæ*). It is there deeply situated at the posterior end of the growing stem, and is covered by several layers of tissue through which it has to penetrate in its further growth. On emerging, it either continues to grow rapidly and form a permanent structure known as the *primary root*, as in the vast majority of plants, or it becomes weakly and ceases to develop, as in most Cryptogams and Monocotyledons. The primary root, where it obtains, develops lateral members, or *secondary roots* ; and the order of succession of these is distinctly acropetal. During the later stages of growth,

however, disturbances in the order of development may occur, and adventitious roots may arise, either on the older primary roots or from parts of the ascending system, i.e., the stem. In the true root the branches break out, and develop by endogenous forking of the growing point; the lateral branches proceed from its pericambial zone. In most monocotyledonous plants the primary root is prolonged downwards, but in grasses it is not developed at all, and numerous roots are given off from the sides of the stem. According to NÄGELI and LEITGER, the secondary roots of cryptogams are, in like manner, produced acropetally, but new roots are probably never formed between these thereafter. The vast majority of roots are formed from stems; more especially from those which have a creeping, climbing, or floating habit, or those that produce bulbs and tubers. Even the *leaves* of some plants produce roots. In the tree-ferns, the whole stem is often densely crowded with numerous delicate roots; and in those species which do not exhibit much exposed stems, as in *Aspidium* (*Lastrea*) *Filix-mas*, and *Asplenium Felix-femina*, the leaf stalks, and in *Mertensia* even the fronds put forth roots. Where, however, the stem has distinct nodes and internodes, the roots are generally given off at the nodes.

The original external form of roots is cylindrical and tapering; but external agencies may greatly modify their shapes. Apart from such considerations, however, roots often take on characteristic forms. They are known as *tap-roots* when the main root is very much larger than those which proceed from it, as in the Dandelion. Varieties of the tap-root are termed *fusiform*, when they are spindle-shaped, as in the carrot; or *napiform*, as in the case of the turnip. When the end of a tap-root is abruptly cut off it is called *premorse*. When roots branch off in a fibrous manner they are said to be *fasciculated*, as in the Dahlia; which, moreover, presents us with an example of a *tuberous* root. Fasciculated roots may become filamentous and are then termed *fibrous*, a mark which distinguishes grasses.

THE MINUTE STRUCTURE OF THE ROOT.—The arrangement of the systems of tissue in the root, differs widely from that of the stem. The fibro-vascular bundles form a radial axis which traverses the centre of the structure, and is sometimes hollow and contains a pith. In very slender roots the pith is absent. The radial bundle is usually surrounded by an external sheath, the *endodermis*, within which a zone of cells is situated termed the *pericambium*. The whole is surrounded by a deep zone of the fundamental cortical tissue, which, as the plant grows older, loses its epidermal boundary, and becomes corky.

In some roots, of which that of the Dandelion is an example, the tissues are capable of an increase, and the structure thus becomes thicker. Many roots, however, are incapable of increased diametral growth, as in grasses; and in these no active cambium layer is differentiated.

In the growth of such a root as that of the dandelion, the vessels of the fibro-vascular system are at first formed near the periphery of the bundle, and thereafter proceed by a *centripetal* growth towards the centre. This, it will be remembered, is directly the reverse of what takes place in the stem. The rows of vessels continue to grow thus until they meet towards the centre of the root, and form a diametral row of three, four, or six rays

along its axis. Between the bundles thus produced, bast bundles usually arise somewhat towards its periphery, and alternate with the vascular bundles. The axial cylinder next undergoes changes whereby its central portion becomes converted into pith, and the formation of xylem and phloëm thereafter becomes peripheral. Increase in thickness of the root is effected by the differentiation of a layer of secondary meristem which is developed between the outer bast bundles and the inner vascular systems; this is a true cambium, and hence behaves in precisely the same way as that layer does in the stem, *i.e.*, by adding bast externally and xylem internally to the tissues of the root. The growth is now, therefore, *centrifugal*.

In the section of dandelion root the arrangement of the tissues, then, very much depends upon its age. If a young root is examined, especially if it is of small calibre, the xylem and phloëm will be seen to alternate with each other around a central pith, which may in very small specimens, be absent; and this is surrounded by a layer of cortex. In roots a little older the central pith can be distinctly made out, although it will be observed that the centripetal order of development of the vessels, indicated by their sizes, is still recognisable. In the fully grown root, which has undergone increase in thickness, the central pith is surrounded by a region in which the vessels are seen to be centripetally developed; these again are enclosed in a layer which has increased centrifugally; then comes a layer of pericambium, outside of which bast bundles are disposed; and finally, an external cortex of somewhat corky cells. In all the sections, whether young or old, the interspaces between the bundles may be detected in form of medullary rays, more especially in young roots.

METHODS OF PREPARATION.

See pp. 14, 16, 85, of this Journal.

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BRONCHUS OF SHEEP.
T.S.m Lung Tissue.
X 30

THE LUNG.

T. S. BRONCHUS OF SHEEP IN LUNG TISSUE.

Stained Logwood.

× 30 diameters.

B. Bronchus, c. Cartilage, a. Artery, v. Vein, l. Lung Tissue.

Etymology.—BRÖN'CHUS, *n.*; pl. BRÖN'CHĪ. [N. Lat. *bronchus*, Gr. βρόγχος, windpipe.]. (*Anatomy*) One of the sub-divisions of the trachea or windpipe.

LÜNG, *n.* [A-S. *lunge*, pl. *lungen*, Icel. *lúnga*, Sw. *lunga*, O. H. Ger. *lungā*, *lungina*, *lunginna*, *lungunna*, N. H. Ger. and Dan. *lunge*, D. *long*.] (*Anatomy*) "The *lungs* of vertebrated animals are sacs, capable of being filled with air, and developed from the ventral wall of the pharynx, with which they remain connected by a shorter or longer tube, the *trachea*, the division of this for each lung being a *bronchus*. Venous blood is conveyed to them directly from the heart by the pulmonary arteries, and some (generally all, but in some *Amphibia*, such as *Proteus*, part of the blood supplied to the lungs enters the general circulation) or all of the blood which they receive goes back, no less directly, to the same organ by the pulmonary veins" (HUXLEY*).

With this limited definition of the term *lung*, therefore, the organ so designated becomes the characteristic respiratory apparatus of only the higher groups amongst the forms of animal life. Organs which approach, in structure and function, the lungs of pulmonated *Vertebrata*, exist in certain fishes, but they cannot strictly be termed lungs in conformity with the definition just quoted; for, in the great majority of cases, the air sacs are usually developed from the dorsal, and not the ventral wall of the pharynx, or from the parietes of the œsophagus or stomach; and their blood supply is not derived directly from the heart, but from adjacent arteries, and is commonly returned into the general circulation. In *Amphioxus*, the respiratory function is typically branchial, and hence does not in any way approach a pulmonary system. Amongst the *Marsipobranchii* the organs of respiration consist of sacs flattened antero-posteriorly, placed at the sides of the pharynx with which they communicate directly or indirectly, and with the exterior. The *Elasmobranchii* present from five to seven flattened pouches with transversely-plaited walls, and these open into the pharynx on the one hand, and externally by clefts on the other.

It is not until we arrive at the *Ganoidei*, that organs which at all approach a pulmonary apparatus, are met with. In addition to their branchial system they possess air-bladders, which are

* *A Manual of the Anatomy of Vertebrated Animals*, London, 1871, p. 92.

permanently connected with the œsophagus by an open *pneumatic duct*. In *Polypterus*, amongst these fishes, the air-bladder is sacculated and paired; its pneumatic duct places it in communication with the ventral aspect of the œsophagus, and it thus approaches nearly in localisation the lungs of the higher animals; but it differs from the latter in that its blood supply is not derived *directly* from the heart.

The air-bladder of the *Teleostei*, is usually sacculated, and shows traces of a bipartition in some, whilst in others it presents numerous diverticula. In the Herring its pneumatic duct opens into the dorsal surface of the œsophagus, and in the Cod, the duct becomes obliterated in the adult; whilst in yet others (*Myripristis*) it is brought into close relationship with the organ of hearing, and may even be connected therewith by specially differentiated ossicles (*Siluroidei*, *Gymnotini*, etc.) It is occasionally absent (*Blennii*, *Pleuronectidæ*, etc.) The anterior internal walls of the air-bladder usually exhibit *retia mirabilia*, but the blood-vessels from which these are derived do not communicate directly with the heart.

Lastly, in the remarkable group of fishes, the *Dipnoi* which present transitional forms between the *Pisces* and *Amphibia*, *Lepidosiren* not only possesses external and internal gills, but is provided with a well developed pulmonary organ of large size, which, in opening on the ventral aspect of the œsophagus by a glottis, communicating with the buccal chamber into which posterior nares also open, and in returning its blood directly to the left auricle of the heart, is fully entitled to the name of *lung*.

In the adult condition, all the groups of the existing *Amphibia*, and probably even the extinct *Labyrinthodonta*, possess lungs. Some of them (the perennibranchiate *Urodela*) are provided with branchiæ in addition to lungs. The membrane of the lung is at first smooth, but becomes finely sacculated after the termination of the bronchus. In many its distal extremity often retains its simple embryonic condition.

In the *Reptilia* the form of the lung varies considerably in the different groups; thus, the bronchus of snakes (*Ophidia*) opens into an enormously elongated sac the walls of which are produced into numerous diverticula, and greatly sacculated at its anterior end, whilst its posterior extremity may remain smooth. The blood supply of these regions also varies to some extent, the smooth portion usually receiving vessels from the general systemic circulation, whilst the region of the air cells is distinctly pulmonary. In external form, the left lung is usually smaller than the right one, and may be rudimentary or altogether wanting, when the posterior portion of the trachea may become modified to subserve part of the functions of respiration. The Lizards (*Lacertilia*) have much shorter lungs than the *Ophidia*, except in the snake-like forms such as *Pseudopus* and *Lialis*; they resemble those of snakes in other respects; and in some (*Chameleon*, *Gecko*), approach to that of birds in the possession of elongated posterior diverticula. In the *Chelonïa* and *Crocodylia* the lungs are finely sacculated throughout their extent. The bronchus traverses the length of the lung and becomes less cartilaginous as it approaches the posterior extremity, but it does not branch thereafter. In the former (*Chelonïa*) they are fixed against the inner lining of the bony carapace, and are only invested by the peritoneum at their ventral aspect, thus resembling the arrangement which obtains amongst birds.

The lungs of birds (*Aves*) are firmly adherent to the surface of the overlying vertebrae and ribs at their dorsal parietes, and are closely held by muscular elements, which arise from the diaphragm and surrounding parts, to be inserted by an aponeurosis upon their ventral surface. The bronchi enter its substance somewhat centrally, lose their cartilaginous rings, and dilating, traverse the length of the organ; in this course they give off branches at right angles, from which other parallel ramifications proceed and ultimately form networks. The ends of the bronchi terminate in a large delicate posterior air-sac, and in its passage through the organ it gives off other canals which terminate in eight other air-sacs; there are thus altogether nine air-sacs, of these two are abdominal, four thoracic, two cervical, and one interclavicular. From these air-sacs a complicated system of branches extends throughout the body, penetrates the bones, and may even give off subcutaneous diverticula.

In *Mammalia*, the bronchi divide and subdivide dichotomously, and terminate in minute air-lobes and lobules. The microscopic structure and relation of these parts to the subjacent tissues will be fully discussed hereafter.

DESCRIPTION.

The organ of respiration in the highest *Vertebrata* forms a paired system situated in the thoracic region of the body, known as the *lungs*, which lie one on each side of the heart and large blood-vessels, and during the life of the animal completely fill the cavity of the chest; thus it is, that the elastic tissue of the lungs is kept continually on the stretch, and hence constantly tends to recoil, so that if an aperture be made into the pleural cavity the lungs instantly collapse, not on account of the pressure exerted by the atmosphere, for that is obviously the same within and without the lungs, but because the distending force is suddenly withdrawn and permits the elastic tissue to regain its former state on removal of the distorting force.

The lungs are attached in the cavity of the chest by only a comparatively small surface at their flattened inner median portion which is termed the *root*, and the thin membranous fold which extends downwards from that part. At all other parts their surfaces are free, closely adherent to the walls of the chest, and invested by a serous sac, the *pleural membrane*, which is reflected over the sides of the thorax and envelopes the lungs on each side. There are thus two *pleurae*, one for each lung, and each pleura consists of a parietal portion, the *pleura costalis*, which covers the convex upper surface of the diaphragm, adheres to the sides of the pericardium, and unites with its fellow in the middle line to enter into the formation of the partition, between the two pleural cavities, which is known as the *mediastinum*; and a visceral portion, the *pleura pulmonalis* which covers the lung.

In the section of sheep's lung, which has been depicted, the transverse section of a bronchus is shown surrounded by lung tissue. The epithelium lining its mucous membrane is seen to be composed of a single layer of columnar cells. KLEIN* has noted that in the larger bronchi the epithelium appears stratified when they are contracted *ad maximum*,

* *Atlas of Histology*, London, 1880, p. 241.

and is seen to consist of only a single layer during distension ; and that the columnar cells of the smaller bronchi vary in height according to whether they are distended or contracted *ad maximum*.

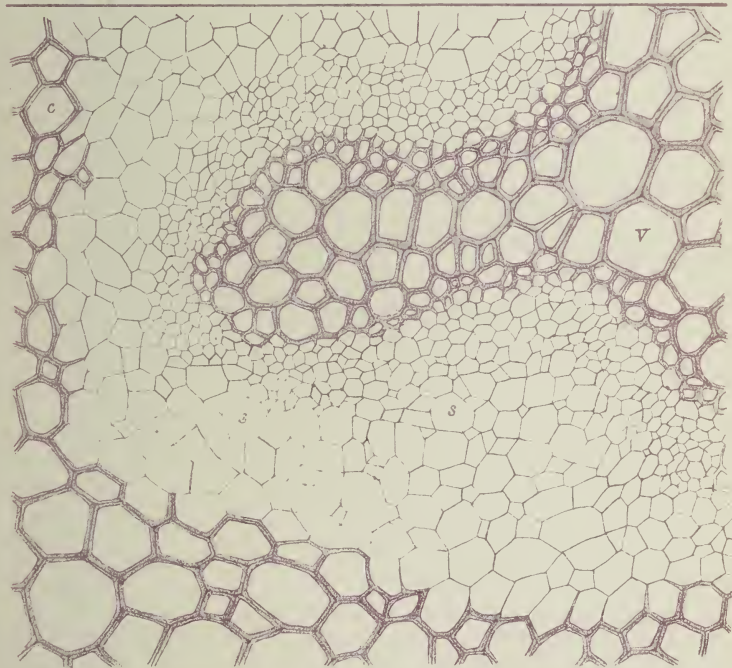
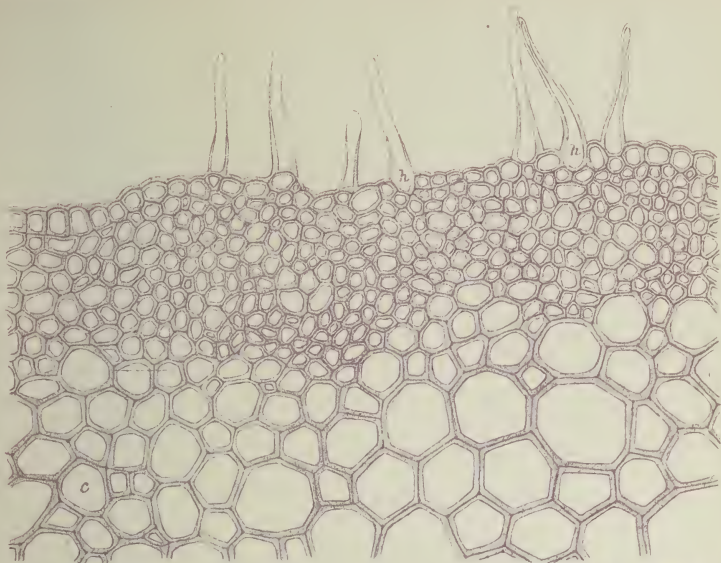
The epithelium is supported below by a clear homogeneous looking band, the *basement membrane*, which, according to DEBOVE, consists of a single layer of large nucleated and flattened endothelial plates.

Underneath this comes the *mucosa* which consists of a delicate network of connective tissue fibres and their corresponding corpuscles, amongst which many elastic elements may be detected by their higher refractive indices.

The mucosa is ensheathed in a layer of non-striated muscular fibres circularly disposed, which varies in depth with the state of contraction or relaxation in which it may be.

Outside the muscular coat comes the *submucous connective tissue*, in which small mucous glands obtain. The arrangement of the tissues in this layer depends upon the size of the bronchi. In the smallest bronchi neither glands nor cartilage occur in this situation ; in those of larger size the cartilage rings (which consist of hyaline cartilage) are lined by a layer of perichondrium into which the fibrous tissue of the submucous coat often pass by trabecular unions. Outside of the cartilaginous rings the connective tissue forms the *adventitia* of the bronchi, which is richly supplied with networks of elastic fibrils ; the adventitia passes thence into the interlobular septa of connective tissue of the lung substance, and in the smaller bronchi merges gradually into the walls of the adjacent alveoli. Where mucous glands occur, they are generally situated between the cartilage plates, and extend towards the adventitia ; and occasionally a small proportion of adipose tissue may be found in the submucous coat.

The blood-vascular supply of the bronchi, and their lymphatic and nervous systems will be considered hereafter in continuation of this description.



del. ad. nas.

West, Newman & Co. imp.

LYCOPODIUM WILDENOVII.

T. S. of Stem

x 300.

LYCOPODIUM WILDENOVII.

T. S. of Stem, Stained Logwood.

× 300 diameters.

e. Epidermis, *h.* Hairs of Epidermis, *c.* Hypodermis, *c.* Cortex, *s.* Sieve-Tube of Phloëm, *v.* Scalariform Vessel of Xylem.

Etymology.—LY'-CO-PŌ'-DI-ŪM, *n.* [N. Lat., fr. Gr. λύκος, wolf and ποῦς, ποδός, a foot, Fr. *lycopode*, Ger. *wolfsfusz*, i.e., wolf's-foot]. (*Botany*) A genus of vascular cryptogamic plants of the order LYCOPODIA'CEÆ, which is constituted by the three families *Lycopodiæ*, *Selaginellæ*, and *Isoëtæ*, of which only three genera are represented in Europe; viz., *Lycopodium*, *Selaginella*. *Isoëtes*.

DESCRIPTION.

The order *Lycopodiaceæ* comprises three groups, which are determined by the affinities of habit and form which they present. The entire cycle of events which follows upon the germination of their spores is as yet only imperfectly understood.

The first family (*Lycopodiæ*) embraces four genera, viz., *Lycopodium*, *Phylloglossum*, *Psilotum*, and *Tmesipteris*, of which *Lycopodium* only is European, and extends as far as the polar regions. The diminutive *Phylloglossum* belongs to Australia and New Zealand. *Psilotum*, the rootless genus, has been found in Madagascar, the Mascarene, the Moluccas, and the Sandwich Islands, and *Tmesipteris* in Australia.

In habit, they are terrestrial, usually perennial plants, and generally of small size. Their stems are herbaceous, and may be creeping, erect, or sarmentose; they branch dichotomously and repeatedly, in indefinite directions, and bear small sessile leaves, which vary but slightly in size, are more or less regular and decurrent, possess a single central stomatiferous vein,* and are arranged spirally upon the stem. In transverse section, the stem is usually circular, but it may be square (*Lycopodium tetragonum*), or compressed (*Lycopodium complanatum*). Numerous adventitious roots are given off from the side of the stem which faces the ground. In most

* Stomata do not occur on the stem in any of the Lycopods; they are confined to the small green or reddish (*Lycopodium rubrum*, etc.), leaves. In *Selaginella* and most of the others, they are arranged in rows on the under surface of the leaves, on each side of the midrib. In *Lycopodium Selago*, a few large stomata are distributed over the whole of the under surface of the leaves.

cases the roots are slender and fibrous, possess an axial fibro-vascular system, and branch dichotomously. *Phylloglossum* possesses a fusiform root.

The second family, *Selaginelleæ*, closely resemble the *Lycopodiææ*. They have procumbent stems which develop dichotomously; but their branches approach the fronds of Ferns, in spreading symmetrically in one plane, and they moreover possess two kinds of leaves; the larger of these form *lateral* rows on each side of the stem, and the smaller are situated *intermediately* between these; there are thus altogether four rows of leaves, which generally clothe the stem closely.

The third family, *Isoëtææ*, is formed of only one genus,—*Isoëtes*, which is distributed over the whole globe. In habit *Isoëtes* is aquatic, and possesses a simple unbranched cylindrical stem, from which elongated awl-like leaves are given off. The stem forms a fleshy sub-ovoid mass, bearing from two to four posteriorly situated furrows, along which it often divides to produce new individuals (*Isoëtes setacea*). From these furrows also, longitudinal series of roots are given off. The stem presents the only example amongst cryptogamic plants, where an increase in diametral growth is perpetuated by the constant addition to it of new masses of tissue. These grow in a peculiar manner, chiefly at two opposite poles outside of the central fibro-vascular bundle; the older tissues pass outwards, decay, and are replaced by the new formations within. In transverse section, the stem thus ultimately takes on the form of a figure eight (8).

The perpetuation of the species, in all *Lycopodiæææ*, is effected in two ways. First, by means of *gemmæ*, or buds, which are produced in the axils of the leaves, and may become detached, or remain connected with the parent stock. In this way a large moss-like colony may be formed, as in *Lycopodium fontinaloides*; and the creeping stem of the British *Lycopodium clavatum* may extend to a length of about 13 feet. Similar instances have been noted in the second family, in which the stem of *Selaginella exaltata* sometimes attains a length of 60 feet (PÆPPIG).

The sexual reproduction of *Lycopodiæææ* is still obscure; it is probable, however, that it resembles the processes which have been observed in other groups of the vascular cryptogams. The fructification takes the form of sporangia, which are borne in the axils of the leaves, often upon special spike-like receptacles. The *Selaginelleææ* and *Isoëtæææ* produce two kinds of sporangia, the *macrosporangia*, and the *microsporangia*. In the former, four large *macrospores* are developed, which, in the course of their growth, produce a prothallium bearing *archegonia*, which open externally, and contain central cells with *oospheres*, thus representing the female element. The *microsporangia* develop numerous small bodies in their interior, termed *microspores*; and it has been observed that these, which are looked upon as *antheridia*, or male elements, are reduced to a few cells, one of which becomes aborted, while the remainder produce *antherozoids*. The process of fertilisation has not yet been distinctly made out, but it has been demonstrated that in *Selaginella*, a filiform pro-embryo is at first produced, from which the young plant is thereafter developed; and that

in *Isoëtes*, the fertilised oosphere, grows directly into an embryo plant. Only microspores have hitherto been detected amongst the *Lycopodiaceæ*.

The economic value of the *Lycopodiaceæ* lies chiefly in the beauty of the forms, and the colour of the foliar organs of cultivated species, which are taken advantage of in the ornamentation of hot-houses, and garden borders; and it is chiefly the *Selaginelleæ* which are used for these purposes.

Lycopodium clavatum is sometimes administered in Russia in cases of hydrophobia; and an infusion of *Lycopodium Selago*, is an emetic, drastic, vermifuge, and emmenagogue. *Lycopodium Myrsinitis* and *Catharticum*, are said to possess purgative properties; and the root of *Lycopodium Phlegmaria*, which is slightly salt, is used by the Indians in checking vomiting, curing pulmonary diseases, dropsy, &c., and also in the composition of potions and philters. The yellow spores of various species, known as *Lycopodium powder*, or *vegetable sulphur* amongst pyrotechnists, is used in the production of artificial lightning; and medicinally, as a powder for rolling pills in, as a desiccator, and a cure for excoriations in the skin of infants (LE MAOUT et DECAISNE*).

ON THE MINUTE STRUCTURE OF THE STEM IN THE LYCOPODIACEÆ.—SACHS† who has studied the formation of the tissues in *Selaginella denticulata*, *Kraussiana*, and *Martensii*, describes a central fibro-vascular cylinder, which belongs exclusively to the stem, and is therefore *cauline*. The tissues may be traced close beneath the apical cell in their procambial condition; and when followed downwards, the bundles of the leaves which are already somewhat advanced, are seen to proceed towards those of the stem, and the development of spiral vessels commences at the re-entrant angle of their union, thereafter advancing downwards into the stem and outwards into the leaf. Thus the fibro-vascular bundles come to be partially cauline and partially foliar, and their growth proceeds in a centripetal direction.

In the species named, a transverse section shows a somewhat elliptical central axis, in the foci of which narrow spiral vessels arise, and from these two rows of spiral vessels thickened in a scalariform manner, pass inwards and gradually become lignified, until a double row of woody vessels comes to lie in the centre of the fibro-vascular bundle. Outside of this the cells are much narrower, elongated, and do not become so lignified; they form a peripheral layer of much wider cells, and together constitute the phloëm portion of the bundle.

In the case of *Selaginella inaequifolia* these fibro-vascular bundles lie side by side, and resemble the single bundles which obtain in the species before named; and in *Lycopodium Chamaecyparissus*, a central axial cylinder occurs in which four parallel bands of xylem, each consisting of a double row of scalariform vessels obtain; the interspaces between them are occupied by their coalesced phloëm portions, in which rows of wider

* *Descriptive and Analytical Botany*, translated by MRS. HOOKER, London, 1876, p. 914.

† *A Text-Book of Botany*, Oxford, 1875, p. 417.

cells may be recognised, and are shown on longitudinal section to be sieve-tubes. The compound vascular cylinder thus formed is surrounded by a peripheral layer of wider cells, the *phloëm sheath* of HEGELMAIER*.

In the *Selaginelleæ* the vascular cylinder is enclosed in a cortex of very loosely arranged tissue, from which transverse rows of cells pass towards the central bundle, and give rise to a structure full of air spaces. In all other Lycopods, layers of thick-walled prosenchymatous cells, and thinner parenchyma form the cortex; the walls of the fundamental tissue, are thus generally much thickened, and especially in contiguity with the axial cylinder.

The epidermal system consists of greatly elongated prosenchymatous cells, and does not exhibit stomata.

ON THE MINUTE STRUCTURE OF THE STEM IN LYCOPodium WILDENOVII.

—A power of about 50 diameters is sufficient to show the general arrangement of the tissues. Thus examined, a transverse section displays a central axial cylinder formed of a single fibro-vascular bundle surrounded by a cortical tissue, the external limitary boundary of which is constituted by a hypodermal zone, and the epidermis. With a high power (about 300 diameters) the systems of tissue just indicated, may be resolved into the following groups:—

1°. A central band of elongated elliptical form, from which three diverticula are given off almost at right angles to the major axis, from one side only. It is composed of thick-walled, polygonal, large elements, disposed in two rows. A longitudinal section shows these to be enormously elongated scalariform vessels, which only rarely exhibit oblique septa. Their dimensions exceed those of the next succeeding zone by from twice to four times, in transverse diameter.

2°. A layer of from one to two cells in depth of scalariform vessels of small calibre. Their cell walls are only about one half as thick as those of No. 1, which they resemble in every respect, except size and location.

3°. A layer of from four to five cells in depth, of elements whose walls are only about one-third the thickness of those of No. 2. The cells are usually hexagonal in outlines, and a longitudinal section shows them to be prosenchymatous in form, with oblique dove-tailed septa.

4°. A zone of polygonal cells with much thinner walls than those of the preceding layer, amongst which occasional larger sized cells may be detected, either singly or in rows. In this region, four cells often meet, and at the junction, a small quadrate intercellular space exists; a mark which usually obtains in the soft bast around the sieve-tubes of most vascular plants. A longitudinal section shows that these larger sized cells are sieve-tubes; the others are parenchymatous, with greatly attenuated walls; and the protoplasmic contents of all the cells is distinctly granular. This layer then represents the phloëm portion of the bundle.

5°. The junction of the cortex and the phloëm of No. 4, consists of a layer varying in depth from one to three cells. It consists of polygonal

* Zur Morphologie der Gattung *Lycopodium*, Bot. Zeitg., 1872, p. 773.

cells, with walls slightly thicker than those of No. 4. A longitudinal section shows it to be composed of parenchymatous cells, which, except in the thickness of their walls, sizes, and situation, are precisely similar to those of the surrounding cortex.

6°. The *cortical parenchyma*. The cells are of polygonal, usually hexagonal outlines in transverse section, and rectangular oblong when viewed longitudinally (about six times as long as they are broad). Their contained protoplasm is scanty and hyaline. Intercellular triangular, and quadrate spaces are also met with in this layer, and in No. 5.

7°. Surrounding the cortex comes the *hypodermis*, which consists of a layer of from eight to ten cells deep. The cells, which are polygonal in transverse section, vary from one-half to one-fourth of the diametral size of the cortical cells, and have walls of about the same thickness as those of the latter. A longitudinal section shows that they are elongated and prosenchymatous.

8°. The *epidermis* consists of a single layer of cells, whose diameters slightly exceed those of the hypodermal cells, and through their situation have assumed somewhat oblong shapes. Their walls are nearly as thick as those of No. 7, and a longitudinal section shows that they consist of greatly elongated prosenchymatoid cells. They are produced at intervals into simple hairs, whose length varies from a mere protuberance to an extent which exceeds the depth of the united epidermis and hypodermal layer.

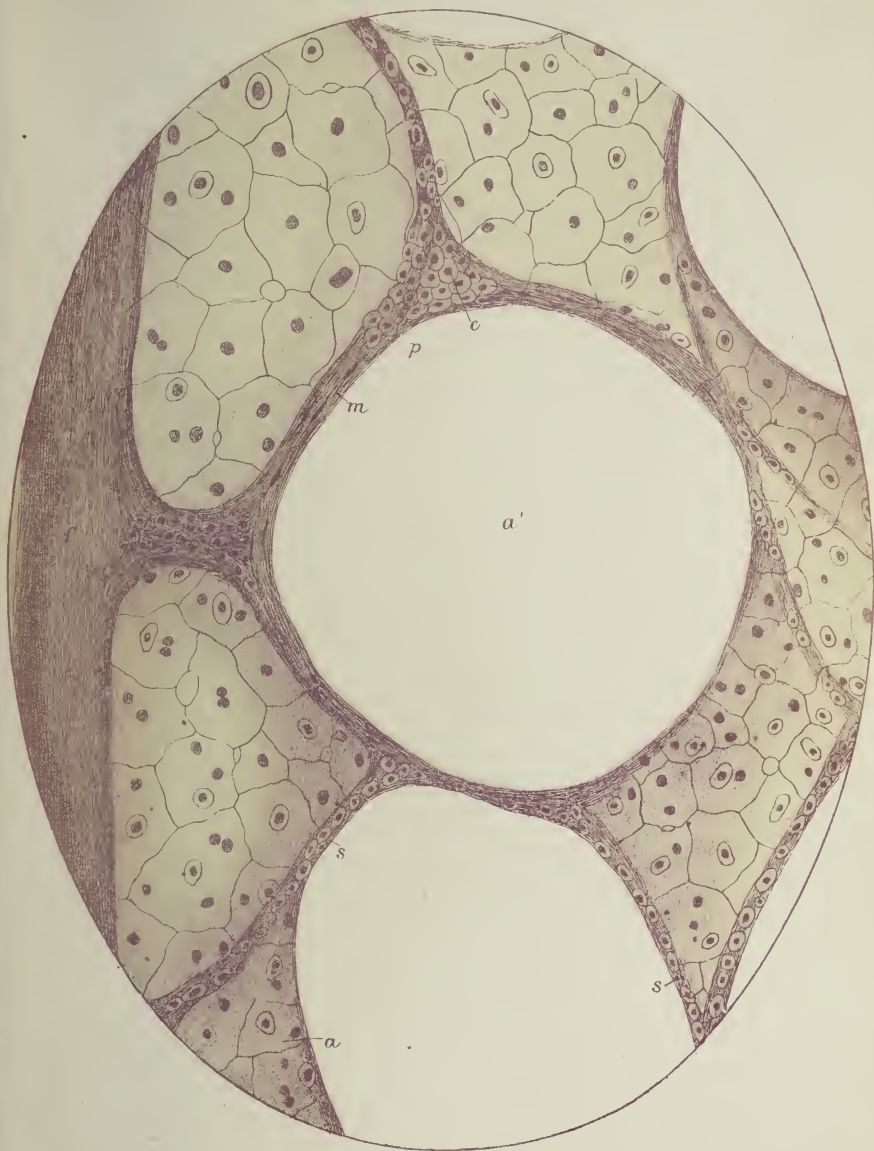
METHODS OF PREPARATION.

See pp. 14, 16, and 85 of this Journal.

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V. S. HUMAN LUNG.
X 315.

From H. W. H. & C. W. H.

del ad nat

THE LUNG.

V. S. OF HUMAN LUNG.

Stained Logwood.

× 315 diameters.

a. Alveolus, *a'*. Alveolar Duct in Section, *s.* Alveolar Septum, *f.* Fibrous Outer Capsule of Lung, *p.* Pseudo-stomata, *m.* Circular Muscular Coat of Alveolar Duct, *c.* A Group of Small Polyhedral Cells continued from the Bronchus.

Etymology.—See p. 148.

DESCRIPTION.

THE MICROSCOPIC CHARACTERS OF THE HUMAN LUNG.—The bronchi on their entry into the lung substance ramify by repeated dichotomies at acute angles ; their primary divisions forming branches which diverge at narrower angles than their ultimate ramifications. Occasionally three branches arise together ; and more rarely still, lateral members are given off from the main trunks. This subdivision goes on without anastomoses, until the final air passages, which have also undergone structural changes, are reduced to minute tubes which vary in diameter from 0·4 — 0·2 mm., and are known as *lobular bronchial tubes*, or *alveolar passages* (F. E. SCHULZE). The alveolar ducts thus formed subdivide and dilate into small conical passages which diverge from each other at acute angles, the basal portion of the cone being distal ; to these ROSSIGNOL has applied the term *infundibula* ; they do not subdivide any more, but their lateral walls are beset with pouch-like dilatations of spherical or polyhedral shapes*, which range in diameter from 0·1128 — 0·3760 mm., and are known as the *air-cells*, *pulmonary vesicles*, *Malpighian cells*, or *terminal alveoli*. ADRIANI has observed, that in the adult body many of the air-cells in the infundibula may coalesce by absorption of their separating walls ; and the side walls of many of the alveolar passages may become covered with vesicles so as to somewhat resemble infundibula (FREY).

What has already been briefly described, constitutes the *parenchyma* of the lung substance. It is bound together by a connective-tissue *framework*, and is richly supplied with *blood-vessels*, *lymphatics*, and *nerves*.

* The shapes of the terminal alveoli are usually spherical, but they become polyhedral when greatly distended ; especially the superficial alveoli.

The Framework of the Lung in Man and the higher *Mammalia*, consists of a close investment of fibrous connective tissue, the *pulmonary pleura*, which forms a *capsule* for the whole organ. From this external layer trabecular septa are given off, which divide and subdivide the structure into lobes and these into lobules. Each lobule, composed of the parenchyma of the lung, is thus encased in a tunic of connective tissue belonging to the framework, and its own tissues blend with those of the former in a manner to be hereinafter described.

The capsule may be distinguished, in the human lung, into an outer dense layer of fibrous connective tissue containing networks of elastic fibres, and corpuscles, known as the *pleural* layer; and an inner *subpleural* layer which is loosely arranged into lamellæ, between which the corpuscles may be detected, and passes by septal ingrowths, into the substance of the organ dividing it into lobes and lobules. It is moreover in continuity with the connective tissue which surrounds the large blood-vessels and bronchi, and forms the adventitia of their system.*

The surface of the pleural membrane is lined by a layer of endothelium whose cells vary in shape and appearance with the contraction or distension of the organ; they are large, flat, and hyaline, when the lungs are fully distended; smaller, thicker, and granular looking on its collapse. KLEINT, who has noted these appearances, also states that its interstitial substance places it in communication with the lymph-canalicular system, and this, in its turn, with the numerous lymphatics which obtain in the sub-pleural tissue. In the guinea pig he has described the existence of a varying meshwork of non-striated muscular cells forming lymph sinuses in the pulmonary pleura, which communicate with its free external surface by means of true stomata.

The Parenchyma of the Lung, consists of structures which have already been enumerated. The histology of the bronchi has already been described†. On reaching the alveolarduct, the epithelial lining of the bronchus loses its ciliated character, and becomes transformed into a layer of low polyhedral somewhat columnar cells, each with a well-marked spherical centrally situated nucleus; within the alveolarduct and infundibulum, some of these cells may be seen forming groups (*c*), and occasionally as isolated elements; they are especially well seen in a profile view of the alveolar wall; but the largest portion of the alveolar walls are lined with placoid shaped cells of much greater size, which closely resemble endothelial plates. In the alveoli themselves these latter predominate; there being but few of the smaller elements left. In appearance the small polyhedral cells are more granular than the placoid plates, and when stained are more readily revealed; they do not seem to be arranged in any definite manner; but their similarity to the forms which exist at the termination of the bronchi has led some observers to suppose that they are distinct from the large flattened cells of the alveoli, and represent a continuation of the bronchial epithelium, whilst to the former a sub-epithelial significance has been delegated. But embryological considerations are adverse to such an ex-

*See this Journal, p. 150.

† *Atlas of Histology*, London, 1880, p. 242.

‡ See this Journal, pp. 149, 150.

planation, for in the lung of the fœtus the alveoli are lined by but one form of cells, the polyhedral granular variety, and KÜTTNER has shown that it is only after respiration, that these become converted into the endothelial form; KLEIN, also, has noted, that during respiration the polyhedral granular forms become placoids when the lungs are distended, and assume their primary shapes on expiration, when the lungs collapse.

Occasionally, between the placoid cells which line the alveolar ducts, infundibula, and alveoli, there may be detected small openings (*p*); these *pseudo-stomata* as they are termed, correspond to the true stomata of serous membranes; in the specimen of lung from which the drawing was taken, the alveoli were distended *ad maximum*, owing to the death by drowning of the subject from whom the tissue was removed; the pseudo-stomata are therefore well shown; but in contracted lungs they are difficult to demonstrate, and may be reduced to mere specks. They communicate directly with the lymph-canalicular system of the alveolar walls (KLEIN).

The connective tissue with its network of elastic fibres and corresponding corpuscles which obtain in the terminal portion of the bronchi, passes into the walls of the alveolar ducts and infundibula, where it becomes excessively delicate, and is greatly diminished in quantity; the walls being chiefly thickened by circular bands of non-striped muscular fibres (*m*).

METHODS OF PREPARATION.

THE SILVER PROCESS.—This process is specially adapted for demonstrating the outlines of the epithelial lining of the alveoli, and in conjunction with logwood staining, reveals all the structural details of the framework and parenchyma of the organ; although logwood, if carefully applied alone, will map out the epithelium quite distinctly.

Kill an animal (preferably a cat or kitten), by bleeding, whilst under the influence of chloroform or ether, by severing the carotid or femoral artery. Divide and isolate the trachea immediately below the larynx, and inject it with a quarter per cent. solution of silver nitrate, until the lungs are fully distended, which may be ascertained by opening the thoracic cavity. Now remove the lungs, and suspend them, with a weight attached below, in alcohol (50 per cent. or good methylated spirit), until required. Cut the lung into pieces, which may be done after twenty-four hours, and make sections in the freezing microtome or imbedded in carrot*. The slices must now be exposed to diffuse daylight, until they assume a dark brownish tinge; they may thereafter be mounted in Canada balsam or stained with logwood or picrocarmine and mounted in Canada balsam, or dammar.

* The lung may be perfectly well cut imbedded in carrot, if the piece of tissue is slightly compressed.

By this method the interstitial substance of the epithelium will be rendered a dark brown, and their outlines thus clearly mapped out; and if a stain be used in addition, it will colour the nuclei, and the connective tissue and other elements generally.

HARDENING THE LUNG, may be accomplished by any of the following methods: it is, of course, desirable to procure a perfectly fresh organ; to kill the animal distend its lungs through the trachea with the hardening reagent, and suspend them a quantity of the same fluid, until the process has been completed.

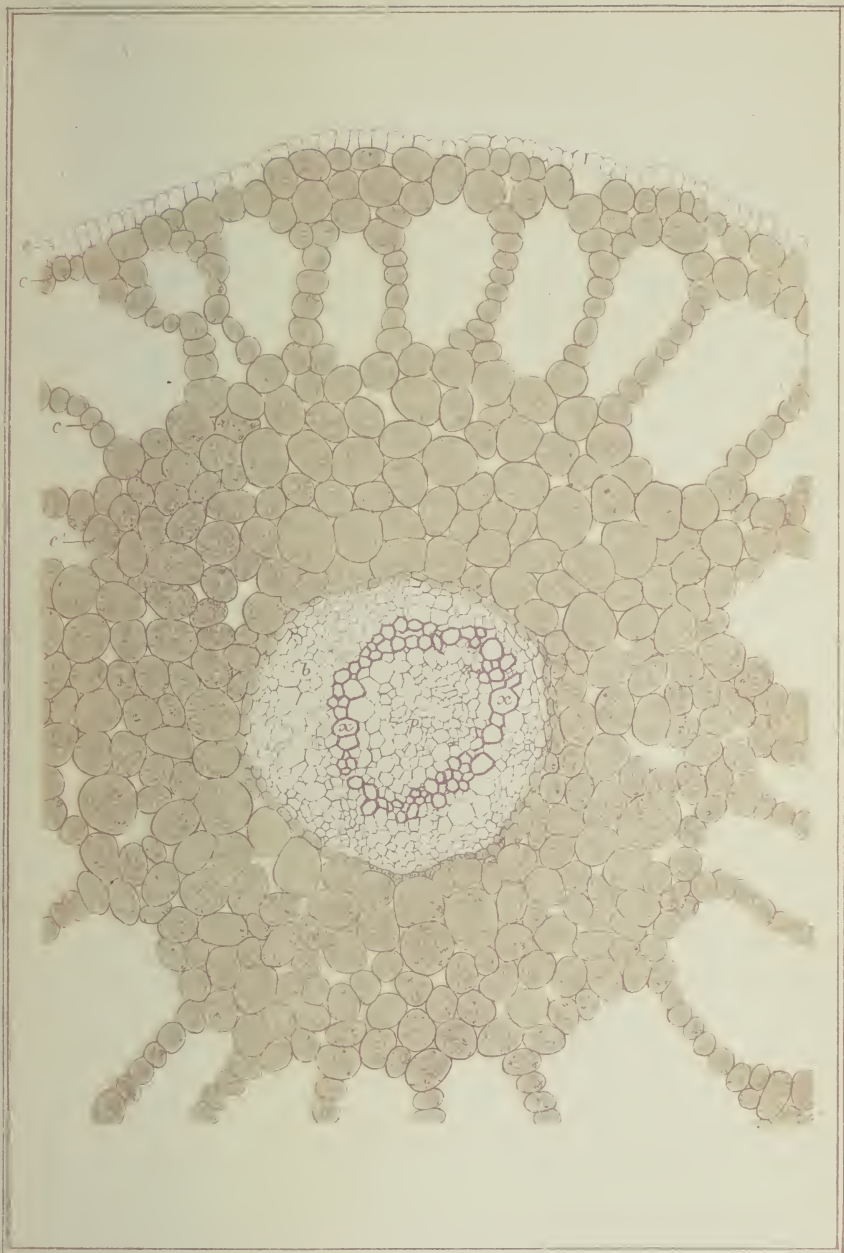
1°. *Methylated Spirit*.—A time varying from two to four weeks suffices; and if the process is carefully watched, very good results may be obtained.

2°. *Chromic Acid*.—A quarter per cent. solution should be used; the organ filled through the trachea, and suspended in the fluid in a wrapping of cotton wool, and the fluid changed at the end of eighteen hours. At the end of about four weeks, the tissues may be cut into pieces, each about half an inch square, and the hardening completed in spirit. In this they may remain until required.

3°. *Chromic Acid and Spirit**. Distend the lungs with the fluid and suspend them in a large quantity of it for twenty-four hours; change the fluid, and after a period of three days cut the organ into small pieces, and place them in fresh fluid for a week; wash thoroughly, and transfer to alcohol until required. (STIRLING).

Sections cut from tissues which have been hardened by any of the foregoing plans, may be stained in logwood, picrocarmine, or carmine, and mounted in Canada balsam or dammar. No. 3 is the best hardening process.

* See this Journal, pp. 40, 70.



PILULARIA GLOBULIFERA

T. S. of Stem.

x 140

PILULARIA GLOBULIFERA.

THE PILLWORT.

T. S. of Stem, Stained Logwood.

× 149 diameters.

e. Epidermis, *c.* Peripheral Cortex, *c'.* Cortical Septa separating the Cortical Air-Channels, *c''.* Perivascular Cortex, *v.* Vascular Bundle Sheath, *b.* Bast, *x.* Xylem, *p.* Central Parenchyma.

Etymology.—PILULA'RIA, *n.* [Lat. *pila*, a ball, *pitula*, a little ball, a pill, Fr. *pitule*, Pr. *pillula*, It. *pillola*, *pillora*, Sp. *pildora*, Ger. *pille*]. So called on account of the pillular form of its sporocarps. (*Botany*), A genus of plants of the order *Marsiliaceae*, and class *Rhizocarpeae*.

GLOBULIF'ERA, *a.* [Lat. *globulus*, dim. of *globus*, a round or spherical body, solid or hollow, a globe; and *ferre*, to bear.]

DESCRIPTION.

The class *Rhizocarpeae* embraces two orders of aquatic plants,—the *Marsiliaceae* and the *Salviniaceae*, and derives its name from the peculiar position of its sexual reproductive elements, which are situated at the bases of the foliar organs, or between the submerged leaves, the teeth of which become metamorphosed into *sporocarps*.

The *Marsiliaceae* are comprised in two genera,—*Marsilia* and *Pilularia*, both of which include perennial plants with filiform stems which creep in the mud of marshy places, to which they are fixed by means of slender fibrous roots, which, like those of Ferns, branch monopodially. The stem is said to exhibit axillary branching by HANSTEIN, but SACHS* is of opinion that it divides dichotomously, and is accompanied thereafter by a cymose development of the forked members in a sympodial manner. The true origin of the branches yet remains to be demonstrated, but SACHS is probably correct in his statements, for the fully developed members are distinctly lateral and not axillary.

The leaves in *Pilularia* are setaceous, erect, and green; in *Marsilia*, the green leaves are borne upon a stalk, and the lobed leaflets which are traversed by fan-shaped dichotomous veins, exhibit the peculiar phenomenon of sleep. Their veneration is, like that of the fronds of Ferns, circinate.

**Text-book of Botany*, English translation, Oxford, 1875.

The fructification of the *Marsiliaceæ*, obtains in the form of closed capsular receptacles, called *sporocarps*. In *Marsilia*, these spring from the outer or lower surface of the leaf stalk, or from its base. In the former instance the sporocarps are usually borne on longstalks which are branched, each division bearing a capsule. When the fructification is basal, the sporocarps have short stalks, and are solitary.

In *Pilularia* the sporocarps are axillary; they are attached to the lower side of the insertion of the leaf, and consist of small pill-like capsules (about $\frac{1}{4}$ in. in diameter in *P. globulifera*), of an ovoid or globular shape, and brown colour; their external coats are richly provided with large brownish hairs. The capsule is divided into compartments by means of vertical dissepiments; *P. minuta* has two, *P. Americana* three, and *P. globulifera* four of these chambers. The sporangia are borne upon cushion-like inward elevations which traverse the peripheral walls of each chamber from the base to the apex of the sporocarp. Both *macro-* and *microsporangia* occur associated together in the same compartment; but, as a rule, the microsporangia are situated above the macrosporangia with reference to the equatorial line of the globular sporocarp.

Thus it appears, that in the disposition of their cauline and foliar organs, the *Marsiliaceæ* approach the *Filices*, whilst through their reproductive elements they form affinities with the *Lycopodiaceæ*.

The *Marsiliaceæ* are distributed throughout the temperate and tropical regions of the world. Both *Marsilia* and *Pilularia* are represented in Europe. In Great Britain only one species is indigenous, viz., *Pilularia globulifera*.*

The sporocarps of several Australian species of *Marsilia*, more notably *Marsilia salvatrix*, furnish the natives with a poor diet which they term “*nardoo*.”

Like the *Marsiliaceæ* the *Salviniaceæ* embrace but two genera,—*Salvinia* and *Azolla*. They are annual aquatic plants, which float upon the surface of the water. *Salvinia natans*, which occurs in the warmer parts of Europe, possesses a floating stem which according to PRINGSHEIM† branches exclusively from the basal part of its submerged leaves, and never exhibits terminal ramification. It bears four rows of flat, green, aerial, leaves on its upper surface, and two rows of dissected leaves on its under surface which depend into the water. The lower surface of the aerial leaves are usually of a claret colour and devoid of stomata.

The sporocarps are situated on the aquatic leaves, of the basal processes of which they are to be regarded as modifications, and are therefore like those of *Marsilia* of foliar origin. They differ from the *Marsiliaceæ* in the possession of sporocarps, which bear their reproduc-

* “*P. GLOBULIFERA*, *L.*; leaves setaceous, capsules pubescent.”

“Edges of lakes and ponds, from Skye and Sutherland, southwards; N.E. and W. of Ireland, very rare; frt. June—Aug.—*Rootstock* or stem 2—6 in., glabrous, cylindric. *Leaves* 2—4 in., green. *Capsules* $\frac{1}{4}$ in. diam., ovoid or globose, shortly pedicelled, in the axils of the leaves or on the rootstock, pubescent, brown, 4-celled.—DISTRIB. Europe N. of the Alps.” HOOKER’s *Student’s Flora*, p 505.

† *Jahrb. f. wiss. Botanik*, 1863, Bd. III.

tive elements in separate conceptacles ; in some of these a small number of macrosporangia are attached by short stalks to a central columnar placenta ; whilst in others, numerous microsporangia are similarly situated on longer stalks. The sporocarps, moreover, decay when ripe, and are not filled with a mucilaginous substance such as that which obtains in *Marsilia* and *Pilularia*.

The genus *Azolla* has been found in all the continents of the world, excepting Europe. Very little is known concerning it beyond what STRASBURGER* has written. *Salvinia* occurs in the northern hemisphere, and in tropical, and South America.

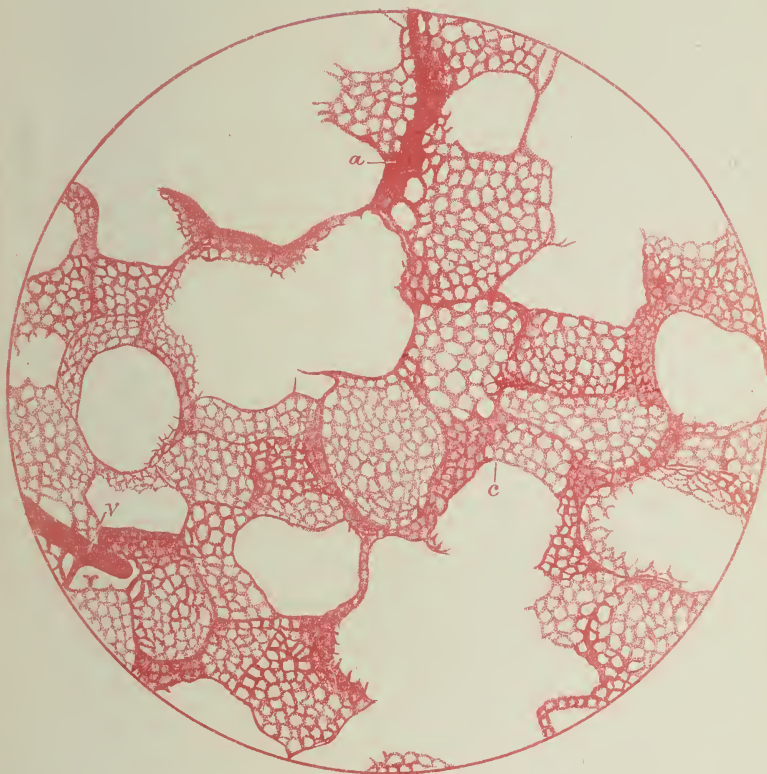
The microscopical characters of the stem and sporocarp of *Pilularia globulifera* will be fully described in continuation of this.

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del. ad nat.

West, Newman & Co. Lith.

LUNG OF CAT.
Injected Carmine
X 145

THE LUNG.

V. S. LUNG OF CAT.

Injected Carmine.

× 145 diameters.

a. Artery, *v.* Vein, *c.* Capillaries.

Etymology,—See p. 148.

DESCRIPTION.

THE BLOOD-VASCULAR SYSTEM.—Two distinct systems of blood-vessels are distributed to the lungs; one termed the *bronchial*, and the other the *pulmonary* system. The former is concerned chiefly with the nutrition of the organ, whilst the latter subserves one of the most important functions of the animal economy in the means which it provides for the aeration of the blood. COHNHEIM and LITEN have denied the statement that the ultimate capillaries of the two systems form anastomoses; but it is highly probable that such a union does exist (HOYER, KÖSTER).

The bronchial arteries arise as ramifications of the systemic circulatory organs, in from one to three branches of the aorta, or from an intercostal artery, and thereafter proceed through the substance of the lungs in association with the bronchi, to the lymphatic glands of which they are distributed. In addition to this they supply the coats of the large blood-vessels which obtain in the connective tissue and muscular walls of the air-tubes, and form a capillary network which spreads over the mucous membrane of those tubes, and is ultimately continuous with the capillaries of the pulmonary system. Branches are also given off, which enter into the delicate interlobular tissue of the organ; and a plexus is formed beneath the pleural investment, the capillaries of which may be distinguished from those of the pulmonary system by their wider arrangement and more or less tortuous course, as well as by their connection with the superficial bronchial veins. The pulmonary pleura is further nourished by twigs which owe their origin to the adjacent intercostal arteries, which penetrate through the *ligamentum latum pulmonis* (TURNER).

The venous blood of the bronchial system is collected by a superficial and deep set of vessels which unite at the root of the lung, and pass into

the *vena azygos* on the right, and usually into the superior intercostal vein on the left side. Part of the blood finds its way into the pulmonary circulation through the capillary anastomoses with that system.

The pulmonary artery, on its entry into the lung, follows the course of the bronchial tubes, dividing and subdividing repeatedly without reference to the branching of the air-tubes. No anastomoses are formed until the region of the alveoli is reached, where a dense capillary network besets the walls of the bronchi and air-cells.

The position of the larger pulmonary arteries and veins, with reference to the bronchi, may be clearly made out in a section such as that depicted in this Journal of the sheep's lung. There it may be seen that the interlobular connective tissue becomes continuous with their adventitia. KLEIN* has observed, especially with reference to the guinea pig, that the circular muscular coat of the branches of the pulmonary artery is often interruptedly continuous, so that at places the adventitia comes into immediate contact with the intima.

The most important portion of the pulmonary circulation,—its capillary network, is very characteristically displayed. The capillaries themselves do not differ in intimate structure from those of other organs. They form a dense network between the pulmonary artery and pulmonary vein. To trace their disposition, it is necessary to have recourse to the methods of injection with coloured masses, and even then it very much depends upon the state of expansion or contraction of the organ. In a fully distended lung the capillary network is seen to form a honeycombed arrangement in each alveolus, the vessels are either straight or slightly wavy; whilst in a contracted specimen they are, of course, very wavy. They lie immediately beneath the epithelial lining of the alveoli, and are thus brought into the most intimate relationship with the inhaled air. The afferent arteriole which gives rise to the capillary network usually serves its purpose for two or more alveoli, and the efferent vein, which conveys the blood away from each diminutive group thus formed, generally passes out at the opposite side to the arteriole. The capillaries of the interalveolar septa, are worthy of special attention; they are very often somewhat twisted, and sometimes dip from one into another alveolus.

It has been observed by ROSSIGNOL that the smaller pulmonary veins, instead of accompanying the arteries and bronchial ramifications in every instance, frequently diverge to take an independent solitary course, and thereafter join some deeper vein situated near a bronchial tube, and form many lateral communications. The veins do not possess valves; they finally unite, and accompany the artery to leave the lung at its root.

THE LYMPHATIC SYSTEM.—The elaborate researches of KLEIN, which are summarised in his *Atlas of Histology*, pp. 245—247, have revealed that the complicated lymphatic system of the lung may be considered under the three following heads:—

* *Atlas of Histology*, London, 1880, p. 245

1°. The *subpleural* or *superficial* (WYWODZOFF) lymphatics, which consist of a dense network of vessels, many of which possess valves, communicate by rootlets with the pleura, but more particularly with the lymph-canalicular system of the walls of the alveoli beneath the pleura. From this subpleural plexus numerous vessels pass through the interlobular connective tissue to become continuous with the next system.

2°. The *perivascular* lymphatics originate in rootlets from the lymph-canalicular system of the alveolar walls, and thereafter accompany and often invaginate the branches of the pulmonary artery and vein. Their larger branches possess valves. They sometimes "*form a dense network of intercommunicating sinuses in the sheath of the large branches of the pulmonary artery*" (KLEIN).

3°. The *peribronchial* lymphatics, the *deep* lymphatics of the bronchi, form a plexus of valvate lymphatic trunks, which accompany and anastomose freely with the perivascular lymphatics, and pass through the interstitial connective tissue of the lungs towards the bronchial glands. The walls of all the lymphatics are constituted of a single layer of endothelial plates.

THE NERVOUS SYSTEM.—The innervation of the lung is a subject which has received more successful attention at the hands of the physiologist than those of the anatomist. Beyond the fact that its tissues are supplied chiefly by the vagi, and partially from the sympathetic system, very little is definitely known.

The fine nervous elements have been traced along the bronchial tubes, and REMAK has stated that white fibres, belonging to the pneumogastric, may be followed along the air passages to the superficies of the organ; and that greyish filaments, evidently of sympathetic origin, which exhibit minute ganglionic swellings, occur both on the bronchial tubes and the pulmonary pleura. ARNOLD also has remarked that the pulmonary nerves of the frog end in pyriform cells.

METHODS OF PREPARATION.

INJECTING THE BLOOD-VESSELS.—Satisfactory results can only be attained, where the organ is procured perfectly fresh; it is therefore advisable to use the lungs of some animal which can be killed for the purpose.

A carmine and gelatine mass should be prepared and kept fluid at a temperature of about 40°C.; the canula of the injecting apparatus should be inserted into the pulmonary artery, which may easily be exposed by opening the pericardial cavity, and the injection commenced. The distension of the organ should be carefully watched. Precautions should be taken to keep the animal or organ in a warm bath previous to injecting. In order to display the capillaries of the alveoli to the greatest advantage, the air-cells of the lung should be also distended.

The most effective plan, and one which can always be relied upon, is to detach the organ from the body with the trachea attached to it, and hang it on a support. Before it has had time to become cold, a quantity

of cocoa butter, melted at a low temperature, should be poured into the trachea through a small glass funnel. The weight of the cocoa butter will be sufficient to carry it into the alveoli; great care must be taken not to overdilate them.

When the preparation has become quite cold, it will be found to be thoroughly filled and supported by the cocoa butter, so that it can be cut up into pieces of about half an inch square with the utmost facility. The pieces should be placed in spirit which should be renewed once every twenty-four hours for the first three days, after which they may remain in the final change of spirit until required.

Thus prepared the tissue may be cut into sections imbedded, in a piece, of carrot or otherwise.

MOUNTING THE SECTIONS.—1°. Soak for an hour in strong methylated or rectified spirit, to remove any water which the sections may contain. 2°. Float the sections on to the surface of a watch-glass full of oil of cloves; this process clears the tissues, and softens the cocoa butter which fills up the spaces in them. 3°. As soon as the slices have been thoroughly permeated by the oil of cloves (i.e., when they sink), they should be transferred to spirits of turpentine, and allowed to remain therein until all the cocoa butter has been dissolved out of the tissues. During this process, they ought to be carefully watched as they are apt to curl up if subjected to the prolonged action of turpentine. 4°. From the turpentine, the sections should be mounted in Canada balsam or dammar solution.

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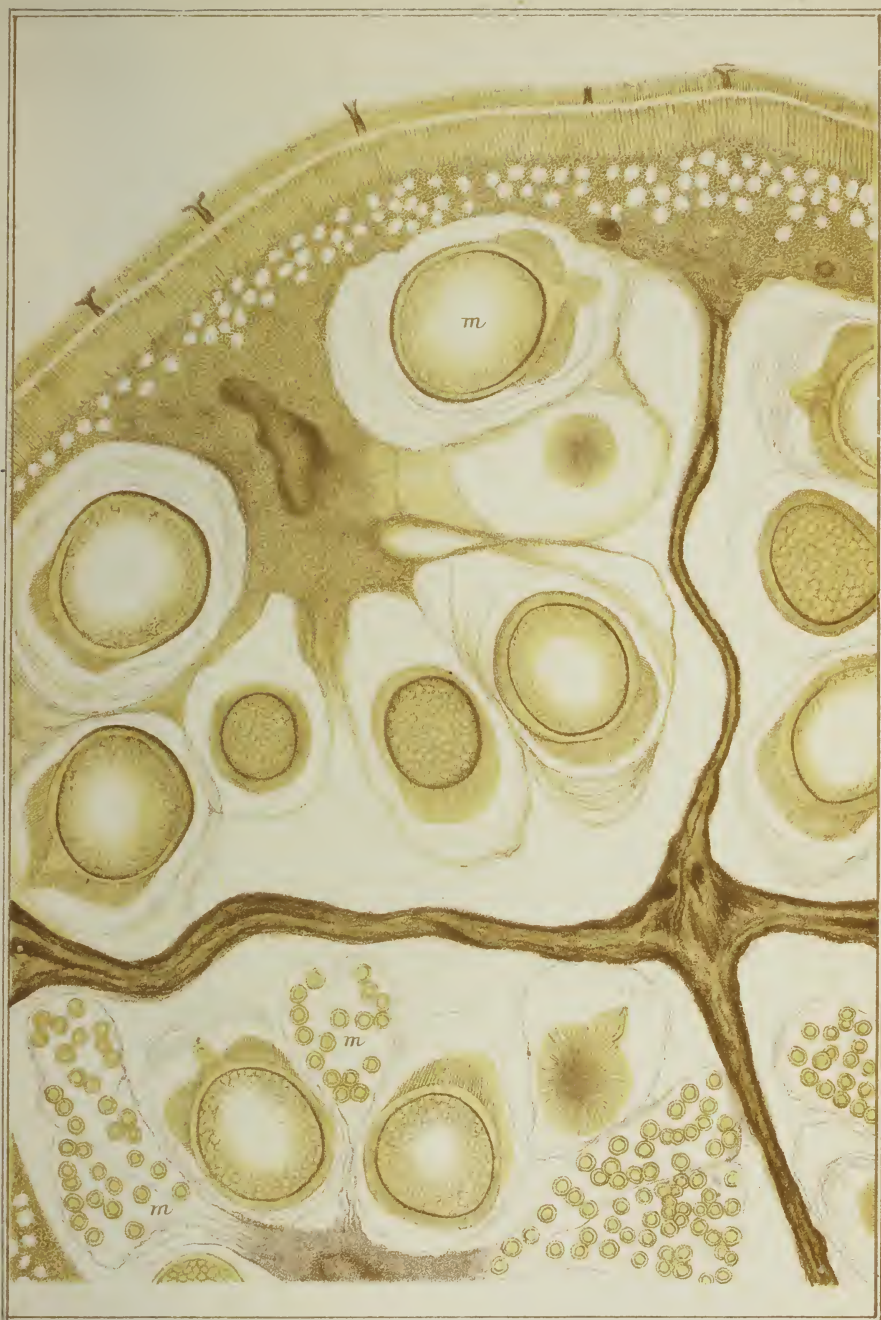
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A. del. ad nat.

West, Newman & Co. Lith.

PILULARIA GLOBULIFERA.

T.S. of Sporocarp.

X 62.5

PILULARIA GLOBULIFERA.

THE PILLWORT.

T. S. of Sporocarp, Unstained.

× 62·5 diameters.

m. Macrosporangia, *m.'* Microsporangia.

Etymology.—See page 161.

DESCRIPTION.

ON THE MINUTE STRUCTURE OF THE STEM.—1°. *The General Arrangement of Parts.*—The systems of tissue which combine to build up the stem structure, may be readily recognised with the aid of a moderately low magnifying power (about 60 diameters), applied to both transverse and longitudinal sections. Thus examined, the stem is seen to be cylindrical, with an axial *fibro-vascular bundle*,* which is surrounded by a single layer of cells—its *vascular bundle sheath* (*v*). The superjacent tissues are constituted by the cortex and epidermis; the former of these is traversed by a lacunar system, which separates it into three divisions, which, for the sake of convenience, I have termed the *perivascular* (*c*), the *interlacunar* (*c'*) and the *peripheral cortex* (*c''*) respectively. The perivascular cortex immediately surrounds the central fibro-vascular bundle; the peripheral cortex underlies the epidermal boundary, and the interlacunar cortex is exhibited in form of radial septa which unite the two last named sections. The *epidermis* (*e*) consists of an external liminary layer.

2°. *Examination of a Transverse Section Under a Power of about 150 Diameters.*—The appearances indicated in the figure at p. 161, represent such a section; there it may be observed that:—

(i). The epidermis (*e*), is composed of a single layer of short columnar cells, the contents of which are hyaline; in very deeply stained specimens, the protoplasm appears to be faintly granular.

(ii). All the cells of the cortex (*c*, *c'*, *c''*,) exhibit subcircular outlines; if any distinction is to be drawn, it may be noted that those of the interlacunar cortex are somewhat less in diameter than those of the other portions of the cortex; the largest cells, perhaps, obtain in the perivascular section. There is a slight tendency amongst these cells towards

* See this Journal, p. 161, and Figure of T. S. of Stem.

polygonal contours, but, as a rule, they maintain their circular outlines ; and, as a consequence of this, numerous intercellular spaces result. The protoplasmic contents of the cortical cells, are characterised by the large proportion of spherical starch granules which they bear.

(iii). The vascular bundle sheath (*v*) consists of a single layer of oblongly elongated cells bearing starch grains which, however, are much smaller than those of the cortical elements.

(iv). The axial vascular bundle develops a median annulus (*x*) of greatly thickened ducts which vary very considerably in size ; in some places they form but a single layer, whilst at other parts they may be two, three, or even four cells deep. Their location and forms (which are polygonal and sharply angular) may be recognised with the utmost clearness with the aid of a polariscope. Under fully crossed nicols they stand out, in an otherwise obscure field, in the form of a highly luminous honey-combed ring. It may, at the same time, be noticed that the starch granules of the cortical cells are revealed as so many brilliant specks. Occasionally, too, the polariscope brings into view other structures which have undergone the ligneous change, such are to be sought for, in minute bundles of equivalent members with sharply defined angular walls, which obtain within the annulus of ducts, and seem to be invested by a sheath whose morphological peculiarities mark it out to be the homologue at least, of the vascular bundle sheath. The central portion (*p*), which is surrounded by the ring of ducts, is composed of an aggregate of thin walled elements, some of which are comparatively diminutive, and are filled with a darkly pigmented sarcode. The interval between the vascular bundle sheath and the median zone of ducts is occupied by cells which unite to produce a system which agrees in all details with the soft bast (*b*), of other vascular plants, in the possession of thin walled large cells, and smaller individuals which usually intervene between them.

3°. *Examination of a Longitudinal Section under a Power of about 150 Diameters.*—As a supplement to the foregoing description, the appearance of a longitudinal section under similar conditions, will bring the following details within the range of observation, and help one rightly to construe the significance of what has been already noted :—

(i). The epidermal cells are greatly elongated with more or less rectangular outlines.

(ii). The cortical cells are about three times as long as they are wide, and have the appearance of so many sub-rectangular parallelograms. It is only exceptionally, that the ends of their major axes are terminated by two sides so as to give the whole cell the shape of an hexagonal prism in section. The intercellular spaces occur in all the three divisions of the cortical system. In the interlacunar cortex these spaces are very minute and somewhat triangular in outlines ; they are so characteristically disposed that VALENTINE* drew special attention to them, especially in the root structure.

* Transactions of the Linnæan Society, Vol. xviii.

(iii). The vascular bundle sheath is marked out by a single band of much elongated cells. Their contents are often darkly pigmented, and they thus stand out in bold relief.

(iv). The vascular bundle itself shows its ducts to be transversely, and spirally striated. The cells which intervene between it and the bundle sheath, exhibit here and there a sieve tube, and intervening elongated cells which are often darkly pigmented. The elements which are included between the ducts, and thus occupy the central portion of the field, do not seem to vary except in size, and in the occasional presence of small darkly pigmented members ; their sides are sometimes wavy, which is probably due to a shrinkage of their delicate walls, a consequence of the methods of manipulation, and their ends dovetail obliquely into one another.

4°. *Examination of Transverse and Longitudinal Sections under a power of about 300 Diameters.*—In addition to the appearances indicated above, the employment of a high power is requisite for the complete resolution of the structures which build up the stem. The cells walls of the epidermal and cortical systems are moderately, and about equally, thick ; those of the annulus of ducts exceed by twice or three times their calibre. The central axis of cells, and those of the bast region and bundle sheath are comparatively delicate. The transverse striæ on some of the larger ducts are due to scalariform thickenings, and the smaller ducts are seen to be ornamented with an internal detachable band spirally thickened.

5°. *Summary of Conclusions.*—(i). *The Epidermal System*, is manifested in form of an external limitary membrane composed of a single layer of moderately thick walled cells, of an elongated parenchyma, whose contents consist of a hyaline faintly granular proto plasm.

(ii). *The Cortical System* consists of a parenchymatous tissue, made up of cylindrical cells, separated from each other by rectangular, rarely oblique, walls of moderate thickness. Instead of being closely packed together, as in the case of the epidermal cells, they retain their rounded walls, and thus give rise to an intercellular canalicular system which pervades the whole of the cortex, and, in the region of the interlacunar cortex, communicates with enormous longitudinal channels which traverse the length of the stem at stated intervals. Provision is thus made for a very complete aëration of this region ; the channels, which are represented as so many lacunæ separated from each other by radial diaphragms in transverse sections, communicate with the canalicular systems of the perivascular and peripheral cortex respectively on the one hand, and open externally through the last named system by means of stomata ; whilst on the other hand their separating diaphragms, which are composed of only a single layer of cells, place the cavities of the channels in direct continuity, by means of intercellular pores or pseudostomata. The rationale of this extensive pneumatic system is to be sought for in the presence of the chlorophyll bodies which are distributed throughout this region.

(iii). *The Vascular Bundle Sheath*, has often been stated to find a place only in the root of Marsiliaceous plants, but its existence in the form of a

single layer of prosenchymatoid cells, which, however, are only delicately walled, cannot for a moment be disputed in this case. The cells contain minute starch grains, and are very often filled with a dark brown colouring material, which, in some instances, is so largely developed, as to form a guide to the situation of these elements in a longitudinal section, which would otherwise be fraught with difficulty.

(iv). *The Vascular Bundle* itself may be said to occupy but one-half of the central axial core, extending from the annulus of ducts to the bundle sheath. The ducts represent its xylem portion, and every here and there between them a woody parenchymatous cell may be discovered. The lignification of the walls of its elements takes place to a remarkable extent, and they acquire a yellowish, and sometimes even a brownish hue. Ramifications of the bundle are stated to pass into the foliar and other organs of the plant. It is only rarely that internal branching occurs; such branching has already been alluded to above, and consists of small bundles of elongated woody cells with greatly thickened walls which diverge towards the centre of the axis, and recurve to unite with the xylem above. In all cases where these aberrant bundles have been noticed, they seem to be enveloped in a perivascular sheath of cells which simulate those of the vascular bundle sheath.

The phloëm portion of the bundle is composed of thin walled sieve tubes and bast parenchyma intermixed. Many of the smaller parenchymatous cells have their contents deeply pigmented with a brown colouring material. Intercellular spaces are absent from every portion of the vascular bundle.

(v). *The Central Parenchyma* corresponds in position with the so-called fundamental tissue of phanerogamous plants, but it differs from that tissue in being composed of greatly elongated cells. To this form of tissue, the term *prosenchymatoid parenchyma*, may be appropriately applied; it consists essentially of a thin walled parenchyma of cells which are enormously lengthened and fusiform in shape.

The minute structure of the sporocarp will be given in the next article.



del ad nat

Trass, Newman & Co.

HUMAN THYROID GLAND.
Transverse Section, double stained
X 150.

THE THYROID BODY.

H. S. OF HUMAN THYROID BODY.

Stained Carmine and Sulph-Indigotate of Soda.

× 150 diameters.

a. Transverse Section of Artery in Superficial Connective Tissue, *α.* Transverse Section of Artery in Intervesicular Connective Tissue, *v.* Transverse Section of Vein in Superficial Connective Tissue, *V.* Vesicle, *b.* Basement Membrane, *c.* Epithelium of Vesicle, *c'.* Epithelium of Vesicle shown as a Membrane, due to Superficial Tangential Section of a Vesicle, *c.* Superficial Connective Tissue, *c'.* Intervesicular Connective Tissue, *c''.* Interlobular Trabecula of Connective tissue.

Etymology.—THYROID, *a.* [Fr. *thyroïde*, Gr. *Θυρεοειδής*, shield-shaped, from *Θυρεος*, a large, oblong shield, from *Θύρα*, a door, and *είδος*, form]. Shaped like a shield.

COMPARATIVE ANATOMY.—A phylogenetic consideration of the development of the thyroid body leads us with W. MÜLLER¹ to a group of organisms, whose place in nature wavers between the two great divisions of the animal kingdom. Amongst the *Ascidians*, a groove-like involution of the ventral aspect of the branchial sac, which is bounded by two lateral folds, has been detected, and is generally known as the *endostyle* or *hypopharyngeal groove*; it remains in permanent continuity with the pharyngeal sac, to which it evidently functions as a mucous gland. W. MÜLLER² demonstrated the existence of a very similar organ in *Amphioxus*, and named it the hypopharyngeal groove; he also showed, that in the *Ammocæte* condition of the Lamprey, a singular groove-like diverticulum, extends from the ventral walls of the throat between the second and fourth visceral clefts. In its ontogeny, this depression becomes gradually reduced to a pore which is situated between the third and fourth permanent visceral clefts, and the organ thus partially cut off, develops paired anterior and posterior cornua, and a median spiral portion, until in the adult condition its opening into the pharynx becomes obliterated, and it takes on the vesicular structure so characteristic of the thyroid body, and remains a ductless gland.

The existence of a thyroid body amongst fishes was first accurately determined and noted by SIMON.³ His investigations, however, did not

¹*Die Hypobranchialrinne d. Tunicaten, Jenaische Zeitschrift*, Bd. viii, 1872.

²*Ueber die Entwicklung der Schilddrüse, Jenaische Zeitschrift*, Bd. vi, 1871

³*On The Comparative Anatomy of the Thyroid Gland, Phil. Trans. Roy. Soc. London*, 1844, p. 299.

lead him further than the statement that "the questionable trace of a thyroid, noticed in the *Petromyzon marinus*, was in a depression of the base of the skull, between the palate and the posterior confluence of the branchial veins; it would resemble the above in being single, but otherwise would be nearer to the thyroids of the osseous fishes."¹

F. M. BALFOUR² in his researches on the embryology of the Elasmobranch fishes, asserts that the Thyroid body is heralded in the early stages of its development, by a diverticulum from the ventral aspect of the throat in the region of the mandibular arch. In *Scyllium* and *Torpedo*, the organ becomes solid, but still retains its attachment to the walls of the pharynx; it thereafter becomes divided into lobes and lobules, and finally loses its connection with the pharyngeal parietes, and develops a lumen.

SIMON³ has remarked, that the Thyroid body of fishes is to be sought for amongst the different members of that group in three situations. In some, as in *Perca*, *Mugil*, and *Trigla*, he failed to discover any structure which bears the slightest resemblance to the Thyroid. In the *Eel* and in certain Elasmobranchs, it obtains as a single median organ in connection with the anterior surface of the intermediate cartilages of the branchial arch, and is very readily exposed. In the *Gadidae* (Cod, Haddock), it forms a paired body, the two parts of which lie one on each side of the anterior end of the first branchial arch. In the *Carp*, *Anableps*, the *Pike* and *Exocoetus*, the gland lies upon the pterygoid muscle, and is often deeply imbedded between the latter and the outer end of the branchial bone.

In his elaborate memoir on *Lepidosiren paradoxa*, BISCHOFF described a minute glandular body, adjacent to the anterior extremity of each cornu of the hyoid bone, which is devoid of any excretory duct; SIMON's⁴ observations with regard to *Menopoma* and *Menobranhus* so nearly accord with this, that he is fully justified in assigning to it the name of thyroid body.

Amongst the *Amphibia* the thyroid body arises as an involution of the region of the mandibular arch. It early develops a two-fold epithelial wall which brings the throat into peculiar relationship with the nervous stratum of the epidermis; the significance of this unique circumstance is still an enigma. Later on it loses its relation to the epidermis, and continues, as in other instances,—an appendage of the pharyngeal cavity.

In the common Frog, SIMON* has stated that the thyroids "are situated on the carotid arteries, just beside the cornua of the hyoid bone, one on each side." Of this, he speaks with absolute certainty, for he notes that

¹*Loc. cit.*, p. 300.

²*A Monograph on the Development of Elasmobranch Fishes*, London, 1878, pp. 223—225.

³*Loc. cit.*, pp. 299—300.

⁴*Loc. cit.*, p. 298.

CARUS¹, although he had discovered them, points to them with hesitation and vagueness. LEYDIG² says that the thyroids of *Batrachia* generally consist of only three large and separate vesicles, which are invested by a close network of blood-capillaries, and contain a finely granular fatty material. The observations of HUXLEY and MARTIN³ and ROLLESTON's figure⁴ are, in like manner, vague and unsatisfactory. In contradistinction to all this, W. MÜLLER,⁵ whose statements tally with those of SIMON, observes that the thyroid body lies, in young frogs, on the two sides of the body of the hyoid bone, immediately above the attachment of the *cornua thyreoidæ*, and is walled in on all sides by muscular fasciculi, and enveloped in a delicate capsular investment, from which blood-vessels enter its substance accompanied by connective tissue, and divide it into vesicular lobes, each chamber of which possesses a *membrana propria*, a lining of unstratified cubical epithelium, and contains a homogeneous, colourless, somewhat viscous fluid. Such a description makes it extremely probable that the structures in question form the thyroid body, and the recent researches of BABER⁶ leave no room for doubt that such is their significance.

In the *Reptilia*, the thyroid body occupies a median position just above the base of the heart, between the carotid arteries. It has often been mistaken for the thymus gland, and is so figured by BOJANUS in his celebrated monograph.⁷ Amongst the *Lacertilia* it may remain median and unpaired, as in *Teius*, *Gecko*, and *Chamæleon*; or double as in *Monitor*, and *Istiurus*. TREVIRANUS,⁸ in his dissection of *Chamæleo carinatus*, describes an organ which he rightly understood to be the thyroid body, close to the hyoid bone, under the sacciform dilatation of the larynx.

The thyroid and thymus glands are so closely associated in the *Ophidia*, that they have very often led to misleading interpretations. On the whole, SIMON's notes seem to be most accurate; he says:—"The following description applies to all the true serpents:—"The gland lies, as in the Crocodile, just above the base of the heart between the right and left carotid arteries; it is a little hidden by the thymus of each side, which lies on the carotid for some distance from the pericardium upwards; and in those genera which possess a fat body (as is, for example, the case with the Python) this large organ lies conspicuously in front of both the thymus and thyroid."

¹*Vergleichende Anatomie*, § 741.

²*Lehrbuch der Histologie*, 1857, p. 376.

³*A Course of Elementary Instruction in Practical Biology*, London, 1877, p. 181.

⁴*Forms of Animal Life*, Oxford, 1870, Pl. iii, p. 181.

⁵*Jenaische Zeitschrift für Medizin und Naturwiss.*, 1871, Bd. vi, p. 438.

⁶*Phil. Trans. Roy. Soc.*, London, 1881, pp. 579—580, and Plate 68, Fig. 1, i.

⁷*Anatome Testudinis Europææ*, Vilnae, 1819—21, Figs. 66, 156, et 173.

⁸*Beobachtungen aus der Zootomie*, p. 87.

⁹*Loc. cit.*, p. 298.

Amongst the *Aves*, we are indebted for our knowledge of the thyroid body to W. MÜLLER¹. The results of his investigations show that towards the end of the second, or beginning of the third day of incubation, in the egg of the Fowl, an outgrowth of the hypoblast in the pharyngeal region takes place, opposite to the origin of the anterior arterial arch. The fourth day shows this protrusion to consist of a solid mass of cells, which becomes bilobed and separated from the epithelium of the throat on the fifth day. The seventh day shows that it has shifted backwards, and that its two divisions have become distinct from each other. On the ninth day a capsular investment of connective tissue grows around its divisions, and sends in inward trabeculae which subdivide its substance into solid lobules of cells. No further changes of importance take place until about the sixteenth day, when it is found in the condition of a paired organ with hollowed vesicles; each of the latter being provided with a membrana propria, and separated from each other by a delicate connective tissue. In its future growth, it gradually passes back to its original locality, at the point of origin of the anterior arterial arch.

The development of the thyroid body amongst the higher *Vertebrata* has been studied by KÖLLIKER² and HIS³. Their researches show that a caecal invagination takes place at the juncture of the anterior pair of aortic arches, but that it soon becomes solid, separates, and shifts its position to the ventral aspect of the trachea, where it undergoes, first of all, a primary bi-partition which, however, is not complete, the two portions being united by an isthmus; and that it afterwards becomes developed into a vesicular organ supported by and invested in a stroma of connective tissue, with its blood-vascular, lymphatic, and nervous systems.

DESCRIPTION.

ON THE MINUTE STRUCTURE OF THE HUMAN THYROID BODY.—It will be gathered from the foregoing notes on the comparative anatomy and development of the thyroid body, that it consists essentially, as in all glandular structures, of a framework and a parenchyma.

Its early development shows, that it consists of a solid mass of sub-spherical cells, derived from the hypoblastic layer of the anterior end of the foregut of the embryo, to which the name *alveolar organ* may with justice be applied, inasmuch as in its subsequent growth it is invaded by mesoblastic ingrowths of connective tissue which first of all envelop the alveolar organ, and then penetrate its substance, dividing it into lobes and lobules, and these into vesicles or alveoli. This state of affairs pro-

¹ *Ueber die Entwicklung der Schilddrüse*, *Jenaische Zeitschrift*, 1871, Bd. vi.

² *Grundriss der Entwicklungsgeschichte d. Mens. u. d. höheren Thiere*, Leipzig, 1880, p. 336.

³ *Anatomie menschlichen Embryonen*, I, *Embryonen d. ersten Monats*, Leipzig, 1880.

gresses actively, until the organ has reached its full maturity, which is probably attained at birth (FREY¹); it thereafter continues to grow tardily, and possibly to degenerate. It thus happens, that whilst some of the alveoli are large, others are comparatively diminutive, especially in early life, and that no definite statement can be made respecting the size of the alveoli, nor their relations to one another. This explanation of its irregular development and degeneration, accounts also for the apparent confluence of some of the alveoli, even in the adult condition, as pointed out by ZEISS² and BABER.³

The *Framework* consists of a capsular connective tissue, with its corresponding corpuscles, arranged in numerous lamellæ, in which many elastic fibrils intertwine. From this superficial boundary (*c*) septa of varying breadth are given off, forming interlobar strands (*c'*) and these, in their turn, ramify to divide the gland into lobules. The interlobular connective tissue merges into a meshwork of fine lamellæ which circumvest the alveoli, and thus produce an intervesicular or interalveolar framework (*c'*), which varies in quantity in different animals; amongst the *Mammalia* it reaches its maximum in Man. (KÖLLIKER.)

The *Alveoli* vary in size, even within the same lobule, but to a less extent in the same than in different individuals.⁴ In shape they may be oval or spherical, or any of the forms which result from their compression. These two factors (size and shape) are dependent upon the state of active or passive secretion of the organ (KLEIN),⁵ and most of them are provided with a central cavity or lumen.

KLEIN⁵ states, that each alveolus is limited by a *membrana propria*, composed of a network of nucleated flattened cells, from which nucleated spindle-shaped or branched elements extend to, and between, the epithelial lining of their cavitory system.

The *Epithelium* lining each alveolus consists of a single layer of low columnar or cubical cells with slightly oval nuclei, which upon distension of the alveoli assume polyhedral forms with spherical nuclei (KLEIN).

To the *Alveolar Contents* which are viscid, semi-fluid, homogeneous, and tinged with a yellowish hue, the name *colloid matter* has been given. Often, spherical or ovoid, highly refractive accumulations obtain within the alveoli, and, together with an abnormal amount of secretion, distend them very considerably. In this state, the interalveolar connective tissue suffers by undue compression, and the whole organ may increase very largely in size, and give rise to the pathological condition known as *goitre* or *bronchocœle*. BABER⁶ has observed that numerous large granular nucleated cells occur in the interalveolar septa, and migrate into the

¹ *The Histology and Histochemistry of Man*, London, 1874, p. 443.

² *Mikros. Untersuch. ü. den Bau der Schilddrüse*, Inaug. Diss., Strassburg, 1877.

³ *Phil. Trans. Roy. Soc.*, London, 1881.

⁴ FREY, *loc. cit.*, p. 441, gives the following dimensions for the alveoli:—They vary from 0.0501—0.1026 mm. in diameter.

⁵ *Atlas of Histology*, London, 1880, p. 433.

⁶ *Quarterly Journal of Microscopical Science*, No. lxvii, July, 1877.

cavities of the alveoli where they undergo degeneration; he has called these elements *parenchymatous cells*. He also discovered quantities of blood within the alveoli, the coloured corpuscles of which greatly preponderate, and occur in all stages of disintegration. To this phenomenon he ascribes the yellowish colour of the alveolar contents which are thus tinged by haemoglobin or one of its derivatives, and unmistakably points out, that one of the functions of the thyroid body is to remove and to destroy the coloured blood corpuscles.

The *Blood-Vascular System* of the thyroid body is manifested in a rich circumalveolar network of capillaries to which afferent and efferent vessels proceed by means of the connective tissue framework.

BABER¹ has described a *Lymphatic System*, which pertains in form of walled sinuses between the alveoli and interalveolar septa which empty into lymph vessels with valves, contained in the interlobular septa, and forming perivascular sheaths around the arterial branches. The efferent lymphatics form a network in the capsule of the organ; they contain a substance which closely resembles that of the alveolar contents, and BABER has been led to conclude from this and from the peculiar arrangement of the circum-alveolar sinuses, that they are concerned in the removal of the alveolar contents.

METHODS OF PREPARATION.

STAINING WITH CARMINE AND SULPH-INDIGOTATE OF SODA. See p. 40 of this Journal. It will be observed that the carmine has stained the epithelial lining of the alveoli, as well as all the nuclei of the connective tissue exclusively, and that the blue dye has acted upon the fibrous portion of the connective tissue, and the so-called colloid matter of the alveoli.

HARDENING THE THYROID BODY.—(i). Place in *Müller's fluid*² for three weeks, and then transfer to spirit until required. (ii).³ Place in *Chromic and Spirit fluid* for two weeks, and complete the hardening in spirit.

¹*Quarterly Journal of Microscopical Science*, No. lxvii, July, 1877.

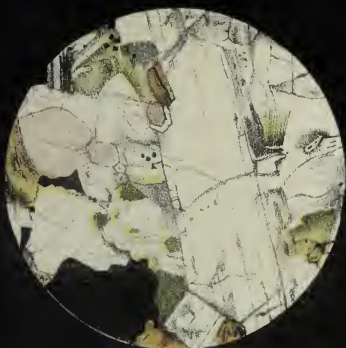
²See this Journal, p. 71.

³See this Journal, p. 70.

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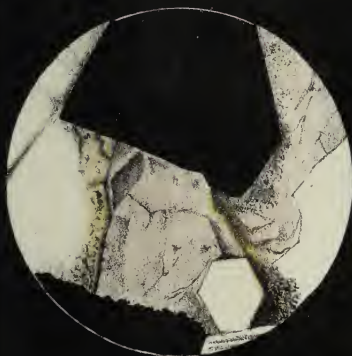
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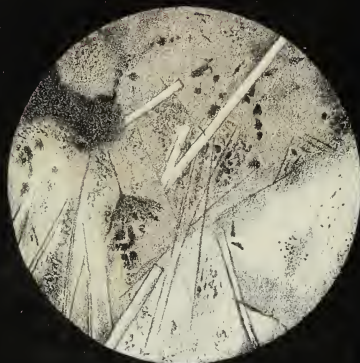
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DOLERITE.

Dalmahoy Hill, Edinburgh.

Nº 1, x 45; Nºs 2, 3, 4, x 65; Nºs 5, 6, x 150.

PILULARIA GLOBULIFERA.

THE PILLWORT.

T. S. of Sporocarp, See p. 173

DESCRIPTION.

ON THE MINUTE STRUCTURE OF THE SPOROCARP.—1°. *The General Arrangement of Parts.*—Under a magnifying power of about 60 diameters, the examination of transverse and longitudinal sections shows that the sporocarp is constituted by an external coat, or *pericarp*, composed of a number of layers, the innermost of which is produced into two septal membranes, which coalesce along the longitudinal axis of the inclosed chamber, and thus divide it into four loculi, which extend from the basal to the apical pole. Within these loculi interseptal median elevations project from their parietes, and give attachment to numerous saccules, the basal ones of which usually support the macrosporangia, whilst the overlying apical ones contain the microsporangia.

In the mature sporocarp, these reproductive sacculi completely fill up the loculi, and as they are not developed with perfect regularity, their distal free extremities often encroach on the regional localities of each other. It thus happens that in transverse sections the two forms of spores are found associated together.

2°. *Examination of a Transverse Section under a Power of about 300 Diameters.*—The external envelope of the sporocarp, which is usually denominated the *pericarp*, admits of a three-fold division, which, for the purposes of description, I shall term *ecto*-, *meso*-, and *endocarp*.

(i). *The ectocarp* consists of a layer of cubical cells, devoid of any well-marked contents; the cell-walls are thin, brownish, and appear to be coriaceous. At intervals some of the cells are produced into T shaped, jointed hairs, which are generally of a deeper brown than the contiguous cells.

(ii). *The mesocarp* is shown in the illustration as a clear, yellowish, homogeneous line. In reality it is resolvible into a layer of delicate hyaline columnar cells, which apparently arise from a basement of minute polyhedral forms; the latter sometimes appear to occupy the whole thickness of the band. In the aggregate under a low power, they form a hyaline membrane.

(iii). The *endocarp* is formed of a single layer of elongated columnar cells, with spherical, basally situated, nuclei, and dark brown cell walls. The columnar form is developed with singularly perfect regularity.

Within the pericarp there exists a membrane, which, in the function it performs of supporting the sporangia, deserves the name of *placenta*. This placental structure is distinguished into two well-marked parts,—an outer and an inner. To the first of these I shall apply the term *circumplacenta*, and to the latter *placenta vera*.

(i). The *circumplacenta* consists of an open network, the strands of which are composed of somewhat oblong cells with thin walls; they contain a very granular protoplasm, and are deeply pigmented with brown.

(ii). The *placenta vera* permits of a further distinction into two parts (a), A *perilocular portion* which merges gradually into the circumplacental membrane, and is composed of thin walled elongated polyhedral elements containing a faintly granular protoplasm. In this layer sections of vascular bundles may be observed; two small bundles obtain one on each side of the commencement of the interocular septa, and may readily be identified by their deeper brownish hue, and closed system of spiral vessels. There are thus eight of these vascular bundle sections in the complete specimen. Besides these, four larger bundles with similar peculiarities lie in the central portion of the cushion-like projection of the perilocular placenta, which lies intermediately in position between the locular septa, and gives attachment to the sporangiferous sacks. (β) An *interocular portion*; the cells of this portion possess all the details of structure observable in the foregoing one, but they are very greatly elongated. They form the septal membranes which divide the cavity of the sporocarp into its four loculi. At the centre of the sporocarp they coalesce to produce a solid axial rod, which is devoid of any vascular elements.

Along the median parietal walls of the loculi, the placenta vera is raised up into cushion-like inward projections, each of which is supported by a centrally placed closed fibro-vascular system. Its superficial layer of cells along these cushions, becomes dilated into pyriform sacks composed of a single layer of cellular plates. Within these sacks the spores are contained.

3°. *Examination of a Longitudinal Section Under a Power of about 300 Diameters.* In addition to the appearances which have been described above, the T shaped hairs of the ectocarp are more clearly distinguishable; the basal cell which forms the perpendicular stroke of the T is seen to be cubical, and otherwise to resemble the cells of the ectocarp in all respects except size; it exceeds in height that of the ectocarpal elements. The horizontal portion of the T, is unicellular, and slightly wavy; its lower limb *i.e.*, that which is directed towards the base of the sporocarp, is usually shorter than its apical limb.

The cells of the mesocarp are clearly shown to be columnar, and disposed side by side with even greater regularity and uniformity of size than those of the endocarp; their columnar form is most easily demon-

strated towards the base of the sporocarp, where they become much more elongated than at other parts. In this situation it may be observed that the basement of minute polyhedral forms, is due to the slight obliquity of their cell walls which come into juxtaposition with those of the next layer.

The endocarpal cells are much wider than those of the foregoing section; towards the peduncular insertion of the sporocarp, they are manifested in form of a stratified layer. The same remark applies to the reticulated tissue of the circumplacenta.

The microscopical appearances of the placental membranes correspond in all particulars with their aspect in transverse sections.

The sporangia are seen to arise towards the central portion of the cushion-like elevation of the placenta vera, and to radiate therefrom in a kind of hemiaster; this may be best observed with a low power. As a consequence of this if a tangential section taken parallel to the longitudinal axis is examined, it will be found that most of the sporangia are cut obliquely or transversely, and that their apposed sides are closely adpressed, so that they assume polygonal contours. It is evident then, that a longitudinal section is not so instructive as a transverse section, when it is desirable to study the structure of the spores themselves, although it shows that the macrosporangia are situated below the microsporangia in each chamber.

4°. *Summary of Conclusions.*—*The pericarp* is composed of three layers:—(i). *The ectocarp* forms a limiting membrane composed of thin-walled, coriaceous, brown, cubical cells. At intervals some of these cells become larger in size, especially in height, and project above the others; they form the basal limb of T shaped hairs, whose perpendicular limb consists of a single wavy cell, the apical portion of which slightly exceeds the lower part in length; the ends of the hairs come to acute terminations.

(ii).—*The mesocarp* is constituted by a single layer of light coloured, hyaline, columnar cells of more or less uniform size. The transverse diameters of these cells vary in length from one half to one sixth of their vertical height.

(iii).—*The endorecarp* cells are of a dark brown colour, rudely columniform, and stratified at the insertion of the sporocarpal peduncle. They are nearly twice as large as those of the mesocarp.

(iv).—*The circumplacenta* is composed of a thin layer (which widens considerably at the insertion of the peduncle) of polygonal parenchymatous cells, with deeply pigmented contents, which form a reticulated tissue, the air spaces of which are not intercellular in the ordinary acceptance of the term, but are bounded by the cells themselves.

(v). *The placenta proper* is formed by a layer of delicate-walled parenchyma which becomes thickened in the region of the cushions which support the sporangia. Its superficial layer forms delicate membranous endothelial sacks for the reception of the spores, and its cells become greatly elongated and fusiform to compose the interlocular septa. The

juncture of the interlocular septa, gives rise to a solid central axis which traverses the sporocarpal chamber from the peduncular insertion to the apex.

(vi). *The Fibro-vascular System* divides into twelve closed bundles of spiral vessels. Four of these are much larger than the others; they traverse the centres of the cushion-like elevations of the placenta in form of longitudinal meridians. The eight smaller bundles are similarly disposed closely contiguous to the right and left of each interlocular septum.

(vii). The brown pigment seems to be a melanotic deposit, which has arisen as a modification of the protoplasmic contents of the cells, or what is more probable, as an elaboration of the protoplasm. In those cells which seem to be devoid of protoplasm, the colour, which evidently was formed in the protoplasm, has become incorporated with the cell wall.

ON THE MINUTE STRUCTURE OF THE SPORANGIA.—VALENTINE¹ has estimated that each microspore measures about 1-460 in., and that there are about 40 microspores in each sack. He has also stated that there are about 60 macrospores in each sporocarp; their average length is about 1-80th-in., and only one is contained in each sack.

The envelope of the microspores is double, and encloses, in the young condition, a granular protoplasm, which, as the microspore develops, undergoes division, and produces small cells, in each of which an antherozoid is formed. The central cavity of the macrospore is filled with a granular substance bearing what seems to be a large quantity of ovoid starch granules.

The structure of the sporangia varies with their age; it is therefore necessary to consider their developmental history. This has been briefly but adequately done by SACHS,² from whose work the following is an extract:—"If a microsporangium is about to be formed, each of the mother cells breaks up into four tetrahedral spores, which all develop into microspores. In the macrosporangium, on the contrary, the mother cells remain, with one exception, undivided; the one, first of all divides in exactly the same manner as the mother cells of the microspores; but only one of the four daughter cells develops any further. In the three others the formation of a rough exospore is commenced, covered by an outer gelatinous layer; this latter soon becomes absorbed, the three abortive spores are arrested in their development, while the fourth at once rapidly increases in size, and grows into an ovoid sac, at first thin-walled, exceeding several hundred fold the size of the three sister cells. The remainder of these abortive sister cells usually remain for a considerable time shrivelled up and hanging to the apex of the macrospore, and may even sometimes be found on it when ripe. The macrospore of *Pilularia* is at first entirely clothed with one coat, but after it has attained about one-third of its ultimate length, it has two, an inner compact brown, and an outer hyaline one. While the spore is growing, this hyaline coat forms a dome-shaped projection at the apex of the spore, and at the same

¹*Transactions of the Linnean Society*, Vol. xviii, p. 483.

²*Text-Book of Botany*, English Edition, pp. 395—397.

time a third coat is formed which is very evidently composed of radiating prisms. These prisms are short at the lower part of the spore, but much longer below its apex, and there form a collar, surrounding the dome-shaped projection already mentioned. On the latter also appears a thin gelatinous layer with a prismatic structure, which, however, is not very clear. Finally when the spore has attained almost its full development, it becomes surrounded with a fourth thick hyaline gelatinous coat which also shows a prismatic structure, but at the same time a concentric stratification. This coat is also not continuous over the apex, but rises above it on all sides forming the outer part of the funnel shaped entrance to the apex of the spore. About this time the dome-shaped bladder-like widening of the second coat at the apex appears to burst and to empty itself; in its place is formed on the ripe spore a conical plicate wart; the true apical papilla in which the prothallus is formed on germination, is formed by an arching of the inner coat which now takes place. The prismatic structure of the two outer coats of the spore may be considered as an evidence of intersecting lamellar systems, perpendicular to the surface of the spores, of denser and softer substance; the third concentric lamellar system is here clearly visible only on the outer coat."

DOLERITE.

Dalmahoy Hill, Edinburghshire.

Etymology.—DŎL'ER-ÎTE, *n.* [Gr, δολερός, deceitful, because it was often confounded with other rocks by the older mineralogists.]

EXPLANATION OF PLATE.

FIG. I. *To show the Felspar, × 45.* The central portion of the field is traversed by a long clear prism of a triclinic felspar, slightly inclined to the left; the prism exhibits well marked longitudinal striæ, and numerous cracks. On the left hand side a pinkish crystal of augite is shown; underneath it there is a brownish patch, evidently the result of a degradation of olivine. Below the latter an ill-defined clear striated felspar occurs, and another similar section obtains above the crystal of augite; both of these felspars embrace minute clear rods of apatite. Between the augite and diametral prism of felspar there are two minute clear hexagons of apatite (transverse sections.) The bottom of the picture shows a black portion, which is a crystal of titaniferous iron, flanked on the right by a brown decomposition product. On the right hand side of the central prism of felspar, nearly the whole of the field is occupied by irregular masses of felspar. The minute patches and dots of black, mark out the particles of iron.

FIG. II.—*Decomposition Products, × 65,* which have probably resulted from the breaking down of the olivinê, and have aggregated as a limonitic deposit of a peculiar mammillated form, around spaces which are filled with a cloudy fibrous zeolite. A transverse clear section of apatite is also shown.

FIG. III.—*To show fresh Olivine, × 65.* This figure has been taken from a perfectly fresh specimen. The crystal of olivine is of a bottle-green colour, and is shown surrounded by an ill-defined mass of clear felspar crystals, which exhibit a few striæ. Above and below the olivine are broken crystals of pinkish augite, whilst towards the left hand side at the bottom of the field a small portion of a ground mass with black trichites and acicular clear crystals of apatite, is shown.

FIG. IV.—*To show decomposed Olivine, × 65.* The chief portion of the field is occupied by a brown crystal, evidently olivine. At the top of the picture an hexagonal section of titaniferous iron is shown. The rest of the field is filled in with felspar crystals, many of which are of a dark colour. Another brown patch gives evidence of further decomposition.

FIG. V.—*To show the Titaniferous Iron, × 150.* The black portions in this figure represent the iron; the pink, the augite; and the clear hexagon, the transverse section of a rod of apatite.

FIG. VI.—*To show the Ground Mass, × 150.* The ground mass is shown devitrified by numerous granules and trichites of iron, and traversed by many clear needles of apatite. On one side the forms field is devoid of granular markings, but exhibits a few acicular of apatite; this portion represents part of an ill-defined mass of felspar.

DESCRIPTION.

In comparatively recent times, when the science of microscopical petrology was still in its infancy, the utmost confusion prevailed in the domain of nomenclature. Greenstone, clinkstone, whinstone, basalt, diabase, dolerite, and even diorite, are terms which were indiscriminately applied to all descriptions of igneous rocks, which exhibit a crystalline texture, and more or less dark colour. Even in the present day, there does not seem to be any unanimity of opinion amongst geologists respecting the classification of rocks, and what one author terms a *basalt*, is called *melaphyre* by another, and *dolerite* by a third.

In Germany, petrologists have repeatedly sought to classify these rocks, by reserving such terms as *melaphyre* and *diabase* for rocks of Palæozoic age; whilst to those of Tertiary and post-Tertiary date, they have restricted the name *dolerite*. Such attempts have deservedly met their fate in ignoring HUTTON's¹ great maxim; and what is still more important, have been shown by microscopical analysis to be entirely without reason.²

The most philosophical classification of the group of rocks to which dolerite belongs, seems to be that indicated by A. GEIKIE,³ which he founded on extended observations over a large area in Scotland. He says:—"Under this title" (the dolerites) "I have since the year 1867 classed the dark crystalline-granular augitic sheets by which the Carboniferous rocks of central Scotland have been invaded, and which were previously embraced under the term 'greenstone,'" and again, "But while no recognisable distinction can be drawn between Carboniferous and Tertiary dolerites, I have been led to discover that a definite line of demarcation can be drawn between the intrusive dolerites and the augitic lavas which have been erupted at the surface. On a former page (*ante*, p. 481) I have referred to some of the broad external features of difference. But the microscope helps still further to discriminate them, and furnishes a valuable assistance in this respect to the labours of the geologist in the field. So reliable indeed are the microscopic tests, that I believe it is possible, in most cases at least, to affirm, even from the small portion of rock placed under the microscope, whether the parent mass consolidated beneath the ground or at the surface."

"Chemically there is probably, as a rule, little or no difference between the intrusive and interbedded sheets. Their differences lie in structure and texture, and point to the opposite conditions under which the rocks acquired solidity. While the intrusive sheets are conspicuously crystalline dolerites, the interbedded are essentially basalts of varying degrees of compactness. *I would, therefore, restrict the term dolerite to the one, and basalt to the other petrographical group.*"

¹ See HUTTON's *Theory of the Earth*, Edin. Phil. Trans., 1788; and his revised volume on the *Theory of the Earth*, 1795; also PLAYFAIR'S *Illustrations of the Huttonian Theory*, 1797.

² See ZIRKEL, *Mik. Beschaff. der Min. u. Ges.*, Leipzig, 1873, p. 291; ALLPORT, *Quart. Journ. Geol. Soc.*, Vol. xxx, p. 529; GEIKIE, *Edinb. Trans. Roy. Soc.*, Vol. xxix, p. 492.

³ *Edinb. Trans. Roy. Soc.*, *ut supra*.

It appears to me, that as the difficulty of a satisfactory classification of these rocks, lies in the diversity of their texture and proximal chemical constitution, it would be wisest for the petrologist to found specific names for each one of them in addition to terms of generic significance, and thus to institute a useful code of terms.¹ The recent researches of FOUQUE and LEVY² have shown that results similar to those existing in nature may be produced in the laboratory; but whilst these confirm the decision against a nomenclature founded merely on the relative age of rocks, they do not as yet afford any clue to a taxonomy based on genetical data.

The rock of *Dalmahoy Hill*, in the neighbourhood of Edinburgh, is, according to A. GEIKIE, a *typical dolerite*. It occurs as an intrusive mass which is supposed to be of Carboniferous age. ALLPORT³ describes it thus:—"The rock is a black dolerite of distinct crystalline texture, composed of plagioclase, augite, and magnetite, with yellowish green pseudomorphs of olivine. The felspar is quite unaltered, and exhibits coloured bands in polarised light. Apatite occurs sparingly in long hexagonal prisms. The spaces between the larger constituents are filled with a felsitic and cryptocrystalline mass instead of the usual glass; in one section this substance also occurs as a small vein, and is crowded with minute hexagonal plates of specular iron."

My own observations have been founded on an examination of nearly four hundred sections of the rock, which was procured in a fresh condition, and for which my thanks are due to my friend Mr. C. G. THORP, of Edinburgh University.

I find, that the vast bulk of the rock consists of a remarkably fresh plagioclastic felspar, which forms an indiscriminate network of prisms. The interspaces of this reticulum are partially occupied by a binding substance, which is devitrified by many acicular and prismatic minute crystals of apatite, black trichites, and a granular felsitoid material. Next in abundance, come numerous irregular patches, and obscurely defined hexagonal and octagonal areas of a yellowish-brown colour; some of these are probably due to a disintegration of the iron constituents; but others, and by far the greatest number of them, I have reason to believe, and will show hereafter, have resulted from the degradation of olivine. A pale, dirty pinkish augite occurs next in quantity to the last-named ingredient, in ill-defined crystals with invariably rounded angles; it often encloses some of the felspar crystals. The iron is represented by large broken plates, and hexagonal crystals of various sizes, and is titaniferous. Magnetite also finds a subordinate place here, and specular iron obtains only presumably. The apatite is generally disseminated in the form of clear slender rods and prisms throughout the field, which is also mottled and streaked with greensish decomposition products, and is occasionally studded with cavities which lodge certain fibrous zeolites.

The FELSPAR, *n.* [Ger. *Feldspath*, from *feld*, field, and *spath*, spar,] which is triclinic, is the predominant constituent of the rock. It is difficult to affirm its variety, as microscopical diagnosis unaided, is insufficient

1 See this Journal, pp. 53, 54.

2 *Synthèse des Minéraux et des Roches*, Paris, 1882, p. 73.

3 *Quart. Journ. Geol. Soc.*, London, Vol. xxx, p. 555.

for such a discrimination. From analogy, however, I am inclined to call it *labradorite*. It is exhibited in form of numerous well-defined, clear striated prisms, and gives the characteristic banded series of colours under polarised light. Some of the crystals show an outcrop of striæ, and interlamellar growths; and when these forms are largely developed, the field acquires a singularly striking aspect.

Under a high power (300 diameters), the crystals of felspar reveal numerous enclosed acicular and prismatic pellucid forms, which undoubtedly are needles and rods of apatite. In some cases the felspar is crowded with these endomorphs, whilst in others they occur but sparingly; they moreover often pass through the crystal, and project into the adjoining parts of the field. Occasionally, larger forms of apatite are seen, and usually show a central dark-speckled core. Granular aggregates shot with black particles also obtain here and there; gas or air cavities are by no means uncommon, and minute cubes (magnetite) and hexagons (titanoferrite) occur more rarely.

It may be observed under a power of about 400 diameters, that diminutive brownish-yellow crystals of the most perfect and regular shape, and others of elongated hexagons built up into peculiar chain-like crystallographic forms, occur at rare intervals throughout the field, but more especially within the boundaries of the felspars. I presume that they are some form of iron, evidently specular iron.

The BINDING SUBSTANCE seems to be composed of a granular felsitic material, which, under a high power, appears to be precisely similar to the substance which is often found within some of the felspar crystals, and imparts to the latter the aspect of a transparent rectangular or sub-rectangular framework. It is pervaded, in some parts, by countless little opaque black rods, and minute squares of magnetite, amongst which a few small hexagonal and irregular forms occur, and reveal the presence of titaniferous iron; in other places no trace of iron particles are discoverable.

Short clear prisms, hexagonal forms, and elongated needles of apatite, also traverse the ground substance in all directions, and when these come into the vicinity of a felspar crystal, they do not tend to lie parallel with its sides but abut against and may even penetrate the felspar—a circumstance which evidences the prior consolidation of the apatite.

The YELLOWISH-BROWN DECOMPOSITION PRODUCTS are undoubtedly limonite; they occur chiefly in the form of irregular patches and discolorations; they also obtain as ill-defined hexagons and octagons. Under a high power they are seen to be crowded with stringy interlaced fissures, which impart a decayed appearance to their substance; and every here and there they weather into minute spherules with dark centres and narrow light borders. In Fig. 2, an aggregation of this brown matter is shown, enveloping a cavity filled with a grey fibrous zeolite; the pisolitic structures with light contours are also clearly depicted.

Amongst the numerous sections which I examined, a few yielded results which are worthy of special notice. In these the yellow decomposition product described above is almost entirely absent, and *in its place* there exists a well-marked perfectly fresh olivine of a bottle-green

colour, presenting a rough surface, and feebly dichroic properties. Fig. 3 represents one of these crystals. The occurrence of the olivine in such good condition, I attribute to the perfectly fresh state of the sample from which the section was obtained. These crystals point out that the yellowish-brown products have evidently arisen, in most instances, as a decomposition of the olivine of which they are, in some cases, pseudomorphs. I may note, here, that the part taken by olivine in the composition of this rock, is at variance with GEIKIE's generalisation¹. "Olivine" he observes, "is rarely recognisable, even as a serpentinous pseudomorph, and never in the freshly crystalline state."

The AUGITE obtains in the form of numerous large ill-defined crystals of a pale, dirty pinkish colour. In nearly every instance the angles of this mineral are rounded off, and many of the crystals are invaded through cracks by lines of decomposition. They often enclose crystals of felspar; and, sometimes, adjacent irregular portions show that they have crystallised around the fully-formed felspar, for they polarise on the same plane in strong colours. With a high power, some of the crystals are seen to contain large particles of iron in the form of both magnetite and titaniferous iron, but, as a rule, they are devoid of endomorphs and cavities.

The mode of occurrence of the iron has been partially described. Titaniferous iron is present in large broken lamellæ, and smaller hexagonal sections which are prone to combine into crystallographic figures, and the Magnetite may be found in minute rods, granules, and occasional square or triangular forms.

Figs. 1, 2, 5, and 6, show the apatite in all its varieties of form.

An approximate estimation of the size of the mineral particles which constitute the rock, may be gathered from the figures, to which accurate magnifying powers have been annexed.

METHODS OF PREPARATION.

See this Journal, pp. 54—61.

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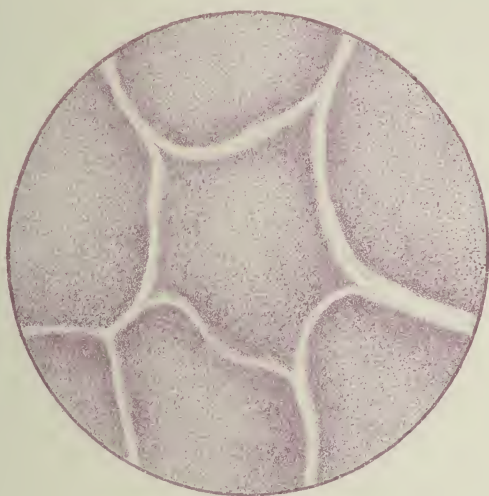
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For the literature on the Methods of Preparation, See this Journal, p. 62.



del. aut. nat.

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H.S. THYMUS GLAND.

From the Calf.

X 65.

THE THYMUS GLAND.

H. S. THYMUS GLAND OF CALF.

Stained Logwood.

× 65 diameters.

Etymology.—THY'MUS, *n.* [N. Lat., Gr. *θύμος*, from *θύειν*, to sacrifice, to smell.] (*Anatomy*).—HUXLEY has described the thymus gland, as an organ developed in the neighbourhood of the primitive aortic arches of all vertebrated animals except *Amphioxus*; double in most of the lower *Vertebrata*, but single in the *Mammalia*, and belonging to the category of lymphatic glands.

The thymus is, amongst the higher *Vertebrata*, an organ of early life, inasmuch as in later times it becomes the seat of fatty degeneration, and usually disappears altogether in the fully matured animal. In the human subject it reaches its maximum development at about the second year of infancy; it ceases to grow thereafter, and gradually degenerates. After the twenty-fifth year it rarely obtains, except as a mere vestige of glandular tissue incorporated in a mass of fat. In its fully developed condition it forms a bilobed organ, of a greyish-pink colour and pulpy consistence, situated in the anterior mediastinum beneath the upper extremity of the sternum.

DESCRIPTION.

The thymus gland consists of a framework of ordinary connective tissue which divides the gland substance into lobes and lobules, and these last into follicles. The gland substance itself, consists of a retiform tissue, in the meshes of which numerous lymph-corpuscles lie imbedded, and give place here and there to cells of other forms.

The *Framework* forms a capsular investment for the whole organ, from which large septa pass into the gland substance and divide it into lobes; from these strands secondary septa are given off, which subdivide the lobes into lobules. These interlobar and interlobular trabeculæ are formed of lamellæ of ordinary gelatigenous connective tissue with their corresponding corpuscles, and a few fine interlacements of elastic fibrillæ. In this respect they are essentially similar in structure to the capsular tissue, which, however, possesses a slight excess of elastic elements.

From the interlobular septa, other branches proceed, which subdivide the lobules into follicles of irregular, cylindrical, or oblong shapes. It may be observed that towards the periphery, the follicles are sometimes of tolerably regular polygonal forms. Elastic fibrils, moreover, are absent from the interfollicular septa, or only occur very sparingly.

KLEIN¹ has noted that "the capsule is surrounded by a continuation of the pleura, a delicate connective-tissue membrane with networks of

¹*Atlas of Histology*, London, 1880, p. 165.

elastic fibrils and numerous capillary blood-vessels, a plexus of nerve fibres, and a few lymphatic vessels; towards the pleural cavity it is covered with a single layer of endothelium."

The *Gland Substance* is arranged within each follicle into an outer denser layer, which is termed the *cortex*, passing gradually into a *medullary* more loosely disposed portion. This is shown very clearly in the illustration, which represents a polygonal follicle from the peripheral region of the organ surrounded by parts of other follicles and the inter-follicular connective tissue. According to WATNEY the medullary portion of neighbouring follicles is often continuous, and the cortical part usually exceeds the medulla in quantity.

Both cortex and medulla consist of a reticular network of flattened plate-like nucleated cells, from which fine thread-like and membranous processes extend to produce the meshwork; they thus retain the primitive embryonic condition, and thereby differ from the elements of ordinary retiform tissue (AFANASSIEW).

The meshes of the reticulum lodge:—1°. Numerous lymph-corpuscles; these are spherical in shape, with large well-defined nuclei surrounded by a narrow layer of clear protoplasm. In the cortical region they are very numerous, and almost completely fill the interspaces; they are also the predominant elements of the medulla, but are not quite so closely packed as in the cortex.

2°. Large endotheloid cells with well marked oval transparent nuclei. These occur but sparingly in the cortex, but are stated by KLEIN¹ to almost fill each reticular space, and to occur at regular intervals, thereby confining the lymph-corpuscles to a narrow zone between them and the branches of the reticulum, and imparting a comparatively transparent aspect to the medulla. WATNEY has noted that some of these endotheloid cells are occasionally granular, and possess from one to three nuclei; and other elements, from these to multinuclear giant cells, are by no means of rare occurrence.

3°. In the medullary region there also occur peculiar cells, which are known as the *concentric corpuscles of Hassall*. Each of these consists of a central nucleated granular protoplasm, around which flattened nucleated plates are arranged in concentric series. AFANASSIEW is of opinion that they are produced by the proliferation of the endothelium of blood-vessels, whose cavities thus become obliterated, and form a solid body composed of concentric lamellæ. WATNEY, on the other hand, supposes that they are concerned in the production of the connective tissue trabeculæ and blood-vessels. They seem to me, however, to approach in structure the nerve endings of certain visceral glands, such as the pancreas of the cat, etc., and although they differ from Pacinian bodies in size, the dissimilarity of their location (the one within the meshes of a reticular tissue, and the other in the connective tissue proper) is not sufficient to decide against their probable nervous origin. The reaction of gold chloride would perhaps help to elucidate this question.

¹*Loc. cit.*, p. 166.

The Blood-Vascular System is supported by the connective tissue framework of the organ. The blood-vessels usually penetrate to the centres of the follicles, and from these capillaries radiate to the cortex. Within the gland substance their outer coats receive accessions from the reticular tissue of which it is partially formed.

The Lymphatic System.—KLEIN has stated that lymph sinuses may be sometimes seen surrounding a portion of the periphery of the follicles. According to HIS, each large blood-vessel is accompanied by two or more lymphatics, which arise from an interlobular plexus; and this in its turn is in communication with the peri-follicular system.

The Nervous System.—Beyond the fact that branches from the phrenic and descendens noni supply the capsule, and that filaments from the pneumo-gastric and sympathetic find their way into the gland, nothing certain is known regarding the nerves.

The Development of the Thymus Gland has been studied by KÖLLIKER and HIS, and more recently by STIEDA. It has been held to be a lymphatic gland, and concerned with the elaboration of the blood in some way. KÖLLIKER¹ has attempted to show that the opinion of its entire mesoblastic origin is probably incorrect, for he found that in the Rabbit it presents in its earlier stages, an epithelial character; and he refers to the investigations of REMAK, which show that numerous glandular bodies are produced, which would occupy the region of the anterior mediastinum, during the degeneration of the posterior visceral clefts of the embryo.

STIEDA'S² observations, made on the Sheep and Pig, confirm KÖLLIKER'S view; the thymus is stated to arise as a bilobed projection from the epithelial remains of a pair of visceral clefts. In the Sheep these are hollow but eventually become solid; in the Pig they are always solid; in both cases, however, they finally unite in the median line.

KÖLLIKER is of opinion that the entire gland substance of the organ is of hypoblastic origin; but STIEDA, and HIS, assert that only the so-called concentric corpuscles are epithelial, and that the adenoid tissue with its contained lymph elements are of mesoblastic derivation.

METHODS OF PREPARATION.

STAINING WITH LOGWOOD. See this Journal, p. 85, etc.

HARDENING THE THYMUS GLAND.—The gland of a calf is preferable to that of the human infant because it can always be freshly procured. Those of the young rabbit, kitten, or pup, do not show the concentric corpuscles very clearly.

(i). *Chromic Acid and Spirit Mixture.*—Follow the directions given at p. 182 of this journal.

(ii). *Picric Acid.*—Harden small pieces in a saturated solution of picric acid made in cold water, and kept saturated by an excess of crystals, for twenty-four hours; transfer to methylated or rectified spirit until required. Sections from tissues thus prepared may be stained with picrocarmine and mounted in Farrants's solution.

¹*Entwickelungsges. d. Mens. u. d. höheren Thiere*, Leipzig, 1879, p. 881.

²*Unters. über d. Entwickl. d. Gland Thymus, etc.*, Leipzig, 1881.

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St. act. ad nat.

Thos. Newcomb & Co. lith.

STICTIA PULMONACEA.

T.S. of Thallus

x 400.

T. S. THALLUS, OF LICHEN.

STICTA PULMONACEA.

× 400 diameters.

c. Supra-Cortical Layer, c'. Infra-Cortical Layer, m. Medullary Layer, g. Gonidial Layer, r. Rhizines.

Etymology.—LĪCHEN (li'ken, or lich'en, *n.* [Lat. and Fr., Gr. λειχήν, Sp. *liquen*, It. *lichene*]. (*Botany*), Fungi which belong to the order *Ascomycetes* (*Discomycetes* and *Pyrenomycetes*), and always occur parasitically associated with certain forms of *Alge*, to produce structures known as lichens (SCHWENDENER).

DESCRIPTION.

Lichens have long been classified in accordance with two morphological distinctions, viz.—external form and texture, and internal structure.

Their external peculiarities mark them out :—1° As *crustaceous*, where the structures grow so closely upon the supporting substratum that they cannot be detached therefrom without injury to their tissues ; examples are to be met with in the so-called pictorial lichens such as *Graphis elegans*, *G. scripta*, and in *Pertusaria Wulfeni*, etc. 2°. By gradual transitions crustaceous lichens pass into more expanded forms termed *foliaceous*. In its typical condition a foliaceous lichen consists of a leaf-like growth, often much branched, and with curled edges ; it is, moreover, but loosely attached to the surface upon which it grows, by slender filamentous processes termed *rhizines* ; and can therefore be readily detached. *Sticta pulmonacea*, *Parmelia parietina*, and others, and are well-known species of the foliaceous type. 3°. When the lichen is attached by only a small basal portion, from which it arises, as from a stem-like origin, to ramify in a foliose manner, it is called *fruticose* ; but it will be readily understood, that there is no sharp line of demarcation between this and the formerly mentioned types, but that, on the contrary, transitional forms link them all together. *Usnea barbata*, and *Cetraria Islandica*, are familiar examples of fruticose lichens. 4°. What seems at first sight to be a marked distinction, is resolvable into one or other of the forms already noted, and furnishes us with a fourth group in the *gelatinous* lichens. They are usually of a slimy consistency, and form firm rounded colloid masses in their natural habitat. *Collema Jacobæfolium*, and *Leptogium*, are good examples of this type.

The intimate structure of lichens distinguishes them into two groups, —*homoiomorous*, and *heteromorous*. The significance, of these terms

can only be fully understood, after the tissues have been microscopically examined. It then becomes evident, that the crustaceous, foliaceous, fruticose, or gelatinous varieties already alluded to, are all built up of two elemental kinds of tissue. The cells of one of these are constituted by spherical, moniliform, or filamentous bodies, usually full of granular protoplasm, and coloured by a green (chlorophyllaceous) or bluish-green (phycochromaceous) tint; to these the term *gonidia* was applied in the days when the nature of the lichen was but imperfectly understood. The other form of tissue is distinctly mycelial; for it is composed of numerous intertwined hyphæ (which may in some parts become peculiarly arranged), precisely similar to the cells of fungal tissue. These two types of tissue become commingled in the formation of the lichen *thallus*, which is said to be *homoimerous* when the two varieties are equally distributed throughout the structure, and *heteromerous*, when they become differentiated into layers which occupy definite areas.

In the growth and development of the thallus, variations in the arrangement of its tissues usually forerun the production of spores; these are formed in peculiar open chambers termed *apothecia*, or in closed receptacles called *perithecia*. It may be noted that wherever these structures are found, they may always be traced to their origin from the mycelial portion of the thallus, and that the gonidial elements do not participate in their essential structure. The receptacles are always generated within the substance of the lichen tissue, and only upon maturity do they seek an external position; their emergence towards the surface is accomplished in either of two ways; they may grow towards the superficial stratum, and there unfold their free *hymenial surface* to the external atmosphere; or they may merely burst when ripe, and produce an orifice through the superjacent layers to admit of the escape of the spores which are developed within them. Lichens which behave in conformity with the first of these methods are termed *gymnocarpous*; those which come under the last category are said to be *angiocarpous*.

ARCHER¹ has noted with reference to *Cænogonium*, and other species which approach it, that they are apparent exceptions to the generalisation which seeks to establish the endogenous production of the apothecia in lichens; in the cases cited by him such an origin becomes impossible, for the hyphal layer consists of but an attenuated zone enveloping the filamentous gonidial region.

If a thin vertical section, taken through the apothecium of such a lichen as *Anaptychia ciliaris*², is examined under a magnifying power of about 500 diameters, the general disposition of the parts which constitute this form of spore producing structure, may be readily observed. The free surface of the apothecium is formed of a layer composed of two kinds of elements, which arise from a closely crowded felt work of hyphæ, and this, in its turn, merges into a looser network of larger hyphæ.

The two kinds of elements first noted, together constitute the *hymenial layer*, and are respectively termed *asci*, and *paraphyses*. Each ascus con-

¹ On *Apothecia in some Algæ*, Q. J. Micr. Sci., 1875.

² SACHS, *A Text-Book of Botany*, 2nd English Edition by VINES, Oxford, 1882, p. 325, Fig. 219.

sists of a sacciform cell, the protoplasm of which becomes divided by free cell formation into a variable number (usually eight) of spores; a small quantity of the protoplasm remains undivided in the form of a peripheral coat to the spores. The spores themselves are generally smooth and coloured brown; they sometimes become multicellular. The paraphyses are placed between the asci, and are usually somewhat club-shaped with darkly coloured distal free extremities.

Both asci and paraphyses arise from a basement of closely arranged hyphæ of small calibre, termed in the aggregate the *sub-hymenial layer*, and this rests upon the *medullary hyphal tissue* of the thallus, which is looser in texture, and formed of larger elements than those of the immediate superjacent structure.

The spores are liberated through the bursting of the apices of the boundary membranes of the asci; their disruption being stimulated by moisture. Under favourable conditions they germinate; the endospore sends out a filamentous process which thereafter becomes greatly ramified; or, in some cases, as many as a hundred germinating filaments may be put forth, as in the large spores of *Megalospora*, *Pertusaria*, and others.

In addition to the apothecia, other structures, known as *spermogonia*, may be found on the same thallus. In general structure they simulate the organs known by the same name in other sections of the Fungi¹. They form pyriform, or globular cavities in the substance of the thallus, and into the lumina of these numerous processes (*sterigmata*) depend; and, as in the case of the apothecia, so here, these structures originate from the hyphal tissue of the organisation. The sterigmata produce, by apical constriction, numerous *spermatia*, which are evacuated from the spermogone when maturity is reached.

Occasionally, other chambers exist in the thallus, which closely resemble the spermogonia. They lodge large sporiform bodies, which arise as the spermatia do, from abstriction of the terminations of large sterigmata; these receptacles have been termed *Pycnidia*.

Yet a fourth modification of the tissues of the thallus, concerned, however, with its asexual generation, remains to be considered. In the non-gelatinous lichens, such as *Usnea*, *Physcia*, *Pertusaria*, etc., a fine powder is detached from the thallus, and usually aggregates into dense masses known as *soredia*. The soredia consist of portions of the gonidial layer which have become enveloped in a hyphal coat; the enclosed gonidia may subdivide, and each new cell thus produced may become similarly invested with hyphæ. This state of affairs may continue within the gonidial layer, until a time arrives when the superstructures can no longer bear the strain; a rupture ensues and the soredia escape, either to multiply as they did before, but more usually to grow into new structures. In some instances, as in the case of *Usnea barbata*, which has been recorded by SCHWENDENER, the soredia may commence to develop into new plants whilst still within the gonidial layer of the parent thallus, and *soredial branches* may thus arise.

¹ For a general description of the structure of the spermogonium, see this Journal, pp 115, 116.

ON THE MINUTE STRUCTURE OF THE THALLUS OF STICTA PULMONACEA.—The thallus requires a magnifying power of at least 400 diameters for the resolution of its elements. It may then be observed that the parts depicted in the illustration are divisible into a number of layers, and that the structure is a typical example of a heteromerous lichen.

1°. The uppermost portion (*c*) may be termed the *supra-cortical layer*. It consists of an areolar tissue formed of short hyphæ arranged in such a manner as to give it a pseudo-parenchymatous aspect. The areolæ form a system of air passages.

2°. Immediately below the supra-cortex the hyphæ become more elongated and form a looser meshwork, the interspaces of which are occupied by certain greenish bodies, termed *gonidia*. Each interspace contains sometimes one, but usually four such bodies enveloped in a hyaline envelope. This area is termed the *gonidial layer*.

3°. The hyphæ of the gonidial layer pass into the next zone, called the *medullary layer*. In this region their cells become larger and are densely matted together; they may be seen to branch dichotomously and their cell-walls are cut in every direction.

4°. The medullary layer passes into the lowermost portion, which may be called the *infra-cortical layer*; it agrees in all structural details with the supra-cortical section, but possesses in addition numerous isolated and transversely connected processes or *rhizines*, which depend from its free surface, and serve to attach the whole thallus to the substratum on which it grows.

We are indebted to the kindness of MR. MUNRO, of Lyme Regis, for the specimens of this lichen, which he gathered from the boughs of apple trees during the summer of this year.



act. ad nat.

Webb, Newman & Co. Inc.

HUMAN PANCREAS
Part of a Lobule
X 333.

THE PANCREAS.

T. S. OF HUMAN PANCREAS.

Stained Carmine.

× 333 diameters.

c. Interlobular Connective Tissue, c'. Inter-alveolar Connective Tissue, t. Gland Tubuli or Alveoli, d. A Lobar Duct.

Etymology.—PĀN'CRE-AS, *n.* [Gr. *πάγκρεας*, from *πᾶν*, all, and *κρέας*, flesh, meat; Fr. *pancréas*]. (*Anatomy*).—The human pancreas “is a long, narrow, flattened gland of a reddish cream colour, larger at one end than at the other, and lying across the posterior wall of the abdomen, behind the stomach, and opposite the first lumbar vertebra. Its larger end, the *head*, turned to the right, is embraced by the curvature of the duodenum, whilst its left or narrow extremity, the *tail*, reaches to a somewhat higher level, and is in contact with the spleen.”¹ The pancreas affords a good example of the compound tubular type, which, with varying degrees of complexity, is characteristic of all save lymph- and blood-glands.

DESCRIPTION.

ON THE MINUTE STRUCTURE OF THE PANCREAS.—1°. *The General Arrangement of Parts.*—The structures which combine to form the aggregate gland-mass admit of a three-fold division into:—(a) *A framework* of connective tissue which also serves as the carrier of the blood-vessels, lymphatics, and nerves. (β) *A canalicular system* composed of the pancreatic duct and its ramifications. (γ) *An alveolar system*.

THE FRAMEWORK consists of a thin capsule of fibrous connective tissue, chiefly of the gelatigenous variety, arranged in form of a lamellar coat, with flattened, sometimes much branched interlamellar corpuscles. From this external investment, inward branches are given off which penetrate the gland substance and divide it into lobes and lobules. The interlobar septa are relatively wider than the interlobular, and serve to carry the larger ducts of the canalicular system. The interlobular tissue gives off delicate strands which envelop the gland alveoli, and in some places seems to be composed chiefly of branched connective-tissue corpuscles, with but a scanty proportion of the white fibrous matrix.

The blood-vessels, lymphatics, and nerves, which will be considered later on, are also borne by the connective tissue, and thus brought into close relationship with the gland substance. It is worthy of remark here,

¹Quain's *Elements of Anatomy*, London, 1876, 8th Ed., p. 394.

that in the pancreas of some mammals, e.g., the cat, the interlobar and interlobular connective tissues often lodge many Pacinian bodies; and it has been observed by BOLL and LAVDOWSKY, especially with regard to the connective tissue of the salivary glands, that isolated groups of migratory cells also obtain in these situations.

The relative amount of connective tissue varies in the glands of different animals; it reaches its maximum development in the human subject, and the division of the organ into lobes and lobules is, therefore, most clearly distinguishable.

THE GLAND SUBSTANCE is composed of two portions; whether these are traceable to a common origin is a question which yet remains to be fully investigated. At all events, their obscure histological relations make it advisable for us to consider them separately.

(i). *The Canalicular System* is formed of numerous minute ducts, which open into larger ones, and these terminate in the principal large duct known as the *canal of WIRSUNG*. In minute structure the ducts vary with their location in the organ, and have hence been divided into distinctive sections. (a). Those which lie in the interlobar connective tissue have been termed *lobar ducts*; they are surrounded by a coat of connective tissue, and KLEIN has observed that in the pancreatic duct, and its larger branches, their walls also possess unstriped muscular fibres. The connective tissue coat is divided from the epithelial lining by a delicate *membrana propria*. The epithelium itself consists of a single layer of columnar cells, which surround a large lumen; each cell is provided with an oval nucleus situated towards the basal attached portion of the cell, whose protoplasm also exhibits a delicate longitudinal striation. (β). The lobar ducts ramify, and in doing so their branches acquire an intralobular position. In this situation they give rise to the *intralobular ducts*; these resemble the lobar ducts in every essential detail; they are, however, smaller in size, and their outer coat of connective tissue is not so largely developed; their lumina also are relatively narrower, and the protoplasm of their epithelial cells is transparent. (γ). The third section comprises ducts which lie between the intralobular canals and the alveoli. They are continuations of the former, and are much branched and of smaller diameter. In length they vary very considerably; they are sometimes long and tortuous, at other times they are so short that they seem to be entirely wanting. LANGERHANS has stated that they are very long in the pancreas of the rabbit. In minute structure these *intermediary ducts* consist of a basement membrane lined by a layer of endotheloid clear cells, each with a flattened oval nucleus, in which an intranuclear reticulum is very well shown (KLEIN).

(ii). *The Alveolar System* consists of a series of branched convoluted tubules with wavy outlines. In sections they present every variety of outline, the result of cutting through a bundle of tortuous tubuli. The interalveolar connective tissue is very delicate and scanty, but yet sufficient to be easily detected. Each alveolar section shows a basement membrane with a flattened nucleus every here and there; it is composed of branched flattened cell plates connected together by means of processes which

are sometimes filiform and sometimes membranous (HENLE, BOLL). BOLL has observed that some of these processes dip inwards between the epithelial cells of the alveoli and there become amalgamated with the interstitial substance which binds them together.

The epithelial cells are of cylindrical or conical forms, arranged in single columnar layers within the alveolar tubuli; where they are conical their conoid apices project freely into the lumina. It may be observed that between each cell an appreciable amount of clear substance may be detected, and that this interstitial material merges into the matter which fills the lumen; the lumen itself is almost obliterated, as the epithelium occupies nearly the whole of the space within the *membrana propria*.

The interstitial cement substance of the epithelium has often been mistaken for an ultimate system of canals which were supposed to communicate with the ducts of the canalicular system. Indeed, SAVIOTTI has even figured them from the rabbit, with the utmost clearness as intercellular capillaries, and his figures have been copied into many text-books, some of which state that these canals may be readily injected with a solution of soluble Prussian blue. VON EBNER pointed out that they were merely clefts without walls in the case of the salivary glands, and HERING denied their canalicular character. LATSCHEBERGER came to the same conclusion with regard to the pancreas. There can be no doubt, however, that KLEIN is right in regarding these so-called intercellular passages as merely a clear cement substance, and that the gland alveoli communicate directly with the terminations of the intermediary canalicular system, in a manner which is not yet precisely understood.

Each epithelial cell shows a marked differentiation of its protoplasm into an outer granular layer, and an inner basal portion which seems to be homogeneous. The spherical nucleus is situated in the clear outer portion (*i.e.* that next the basement membrane) near its line of junction with the granular part; it contains a distinct reticular network (KLEIN). The effects of carmine and logwood are useful here; they stain the outer clear band with its contained nucleus very readily, whilst they merely tinge the granular inner stratum in its fresh condition; this is partially due to the existence of fatty particles in the latter. In specimens which have been well hardened the dye acts more equally, and stains the whole cell deeply after prolonged action. The homogeneous outer layer, according to PFLÜGER, consists of a delicate zone of longitudinally disposed fibrillæ; and KLEIN asserts that the granular appearance of the inner part is due to a network of short thick rods, which may be detected by viewing the cell substance obliquely; seen from the top these rods look like so many coarse granules.

The interesting researches of HEIDENHAIN have shown that these intracellular appearances vary with the activity of the organ. Commencing digestion exhausts the granular zone, and the whole cell becomes smaller, but the homogeneous outer band increases slightly in bulk. As digestion goes on, a restitution of the cell contents takes place; the inner granular layer becomes much larger at the expense of the outer homogeneous one, which dwindles down; at the same time the whole cell increases consider-

ably in size. Experiments on the pancreas of the living rabbit revealed to KÜHNE and LEA, that during digestion the outer borders of the cells become more distinctly striated, and the walls of the alveoli are notched,—the result of the increase in bulk of the epithelial cells; whilst in the passive condition the alveoli remain smooth.

Within the lumen of the alveoli branched flattened endotheloid cells with oval nuclei may be detected; these are the *centroacinar cells* of LANGERHANS. Their precise relations to the other structures have not as yet been satisfactorily made out; whether they are a direct continuation of the cells of the intermediary ducts of the canalicular system or not, is still a matter of doubt. In the former case the alveolar epithelium would be included between the *membrana propria* and the epithelium of the canalicular ducts, and may be looked upon as a modified epithelium specially differentiated for the fulfillment of definite functions in the economy of the gland.

METHODS OF PREPARATION.

The fresh pancreas may be best studied in the smaller Rodents. In the rabbit the glandular alveoli are thinly spread out over a large area of the mesentery, and the pancreatic duct opens considerably below the biliary duct (about a foot below), into the duodenum. In other mammals the gland is so compact that its minute structure can only be studied by means of teasing, and by sections of the fresh or hardened gland.

HARDENING THE PANCREAS may be accomplished by any of the following methods:—

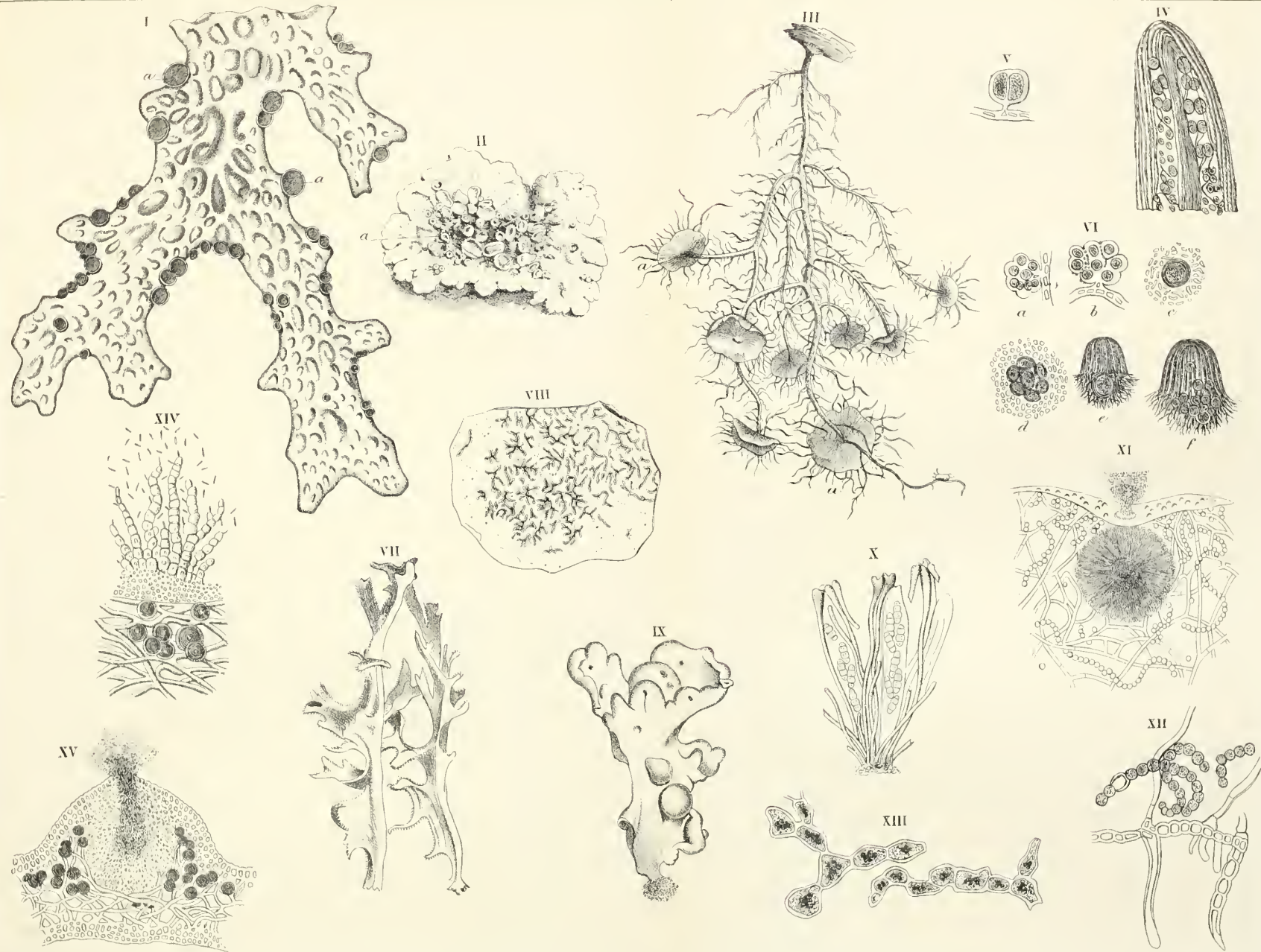
(i.) *Strong Methylated Spirit*.—The fresh pancreas cut into pieces of about half-an-inch square, should be placed in a large quantity of the spirit, which ought to be changed once every day for the first three days. The hardening should then continue in the final change of spirit for three weeks or a month; sections may then be cut.

(ii.) *Absolute Alcohol*.—Forty-eight hours suffices to harden small pieces of fresh pancreas, and fit them for section cutting.

(iii.) *Picric Acid*.—A saturated solution should be used. Very small pieces hardened in this fluid for forty-eight hours, should be transferred to dilute and then to strong alcohol, until they are required. The sections should be stained with picrocarmine, or left unstained, and mounted in Farrants's solution.

(iv.) *Osmic Acid*.—Small pieces should be hardened for two days in a $\frac{1}{10}$ th per cent. solution, and the process continued thereafter in alcohol. Sections thus prepared should be mounted in potassium acetate solution, or in Farrants's liquid; they also admit of successful dissociation with needles.

STAINING WITH CARMINE AND LOGWOOD.—Sections taken from material hardened by the two first methods, may be stained with either Carmine or Logwood, and mounted in Canada balsam or dammar solution. See this Journal, pp. 6, 15, 40, 85—86.



T. S. THALLUS OF LICHEN.

STICTA AURATA, LYME REGIS, DORSETSHIRE

EXPLANATION OF PLATE.

- FIG. I.—*Sticta pulmonacea*, a foliaceous lichen with apothecia (*a*). [Copied from LE MAOUT and DECAISNE, *Descriptive and Analytical Botany*, p. 942.]
- FIG. II.—*Parmelia tiliacea*, a foliaceous lichen with apothecia (*a*). [Copied from LE MAOUT and DECAISNE, *Op. cit.*, p. 942.]
- FIG. III.—*Usnea barbata*, a fruticose lichen with spoon-shaped apothecia (*a*). [Copied from THOMÉ'S *Botany*, English Edition, p. 285.]
- FIG. IV.—*Usnea barbata*, L.S. through apex of thallus; the cortex, the gonidial layer (*g*), and the medullary tissues, are clearly shown; $\times 515$ diameters. [Copied from THOMÉ'S *Botany*, English Edition, p. 285.]
- FIG. V.—*Usnea barbata*, a single gonidium $\times 700$ diameters. [See THOMÉ, *Op. cit.*, p. 285.]
- FIG. VI.—*Usnea barbata*, development of soredia (*a*). Gonidial group of eight cells; (*b*). A similar group more advanced; (*c*). L.S. of mature soredium; (*d*). The same as (*c*) with the gonidia more distinctly separated; (*e*). A germinating soredium; (*f*). The same as (*e*) further developed. ($\times 500-700$). [See THOMÉ *Op. cit.*, p. 285.]
- FIG. VII.—*Cetraria Islandica*, a fruticose lichen; the margin of the thallus is fringed, and bears spermogonia on the edge of the fringe; there are no apothecia.
- FIG. VIII.—*Graphis elegans*, a crustaceous lichen of the pictorial variety, natural size. [See LE MAOUT and DECAISNE, *Op. cit.*, p. 942.]
- FIG. IX.—*Collema Jacobaeifolium*, a gelatinous lichen. [See LE MAOUT and DECAISNE, *Op. cit.*, p. 942.]
- FIG. X.—*Collema Jacobaeifolium*, sporangia and paraphyses. [See LE MAOUT and DECAISNE, *Op. cit.*, p. 942.]
- FIG. XI.—*Collema Jacobaeifolium*, V.S. of a spermogonium from which the spermatia are escaping, after TULASNE. [See LE MAOUT and DECAISNE, *Op. cit.*, p. 942.]
- FIG. XII.—*Malotium Hildenbrandii*, portion of under side of thallus with moniliform chains of gonidia, after DE BARY, $\times 390$. A gelatinous lichen. [See THOMÉ, *Op. cit.*, p. 287.]
- FIG. XIII.—*Graphis scripta*, a crustaceous lichen of the pictorial variety $\times 390$. [See THOMÉ, *Op. cit.*, p. 286.]
- FIG. XIV.—*Parmelia parietina*, Spermatia of 3-500th—1-100th in., after TULASNE. [See LE MAOUT and DECAISNE, *Op. cit.*, p. 943.]
- FIG. XV.—*Parmelia parietina*, V.S. of thallus, and of a spermogonium from which the spermatia are escaping, after TULASNE. [See LE MAOUT and DECAISNE, *Op. cit.*, p. 943.]

SCHWENDENER'S THEORY.

1869 is memorable in the annals of lichenology as the year in which SCHWENDENER first gave to the world a treatise¹ embodying his views concerning the true nature of lichens, founded on morphological studies. His researches led him to conclude that lichens are *ascomycetous Fungi* which have hitherto been discovered only in association with the host upon which they live as parasites, and that their victims are *Algae*. In support of his doctrine he gives the following examples of lichens, and assigns to each its algal host:—

I. BLUISH-GREEN ALGÆ. (*Nostochineæ*).²

Name of Group of Alga	Lichen in which they occur as Gonidia.
(1). SIROSIPHONÆ	<i>Ephcebe</i> , <i>Spilonema</i> , <i>Polychidium</i> .
(2). RIVULARIÆ	<i>Thamnidium</i> , <i>Lichina</i> , <i>Racoblenna</i> .
(3). SCYTONEMÆ	<i>Heppia</i> , <i>Porocyphus</i> .
(4). NOSTOCACEÆ	<i>Collema</i> , <i>Lcmpholemma</i> , <i>Leptogium</i> , <i>Pannaria</i> , <i>Peltigera</i> .
(5). CHROOCOCCACEÆ	<i>Omphalaria</i> , <i>Euchylium</i> , <i>Phylliscium</i> .
(6). CONFERVACEÆ (<i>Cladophora</i>)	<i>Cænogonium</i> , <i>Cystocoleus</i> .
(7). CHROOLEPIDÆ	GRAPHIDÆ, VERRUCARIÆ, <i>Roccella</i> .
(8). PALMELLACEÆ	Many fruticose and foliaceous lichens
<i>Cystococcus humicola</i> ..	<i>Physcia</i> , <i>Cladonia</i> , <i>Evernia</i> , <i>Usnea</i> , <i>Bryopogon</i> , <i>Anaptychia</i> .
<i>Pleurococcus</i> ..	<i>Endocarpon</i> , and various crustaceous lichens.
<i>Protococcus</i> ..	<i>Cladonia</i> , <i>Physcia</i> .
<i>Stichococcus</i> ..	<i>Sphæromphale</i> , <i>Polyblastia</i> .
(9). COLEOCHÆTÆ (<i>Phyllactidium</i> , Kütz.) ..	<i>Opegrapha filicina</i> .

It is a well-known fact that parasitism characterises the life-history of Fungi; their tissues are built up of elements which would decay and die away unless they are nourished by a pabulum, which is elaborated for them, either through the agency of animals, or by other plants. In the case of the *Æcidomycetes*, we noted how the tissues of higher plants are invaded, and how they undergo profound alterations through the ravages of the little cluster cup. The *Æcidium* which attacks the tissues of *Euphorbia Cyparissias*, induces even more remarkable changes, which may often result in a total variation in the habit of the plant.

The examples which have just been cited, are so clearly instances of plants with parasitic fungi upon them, that it has never occurred to anyone to describe the vegetable hosts with their parasitic pests as a distinct group of plants. Yet, there are many who fail to understand SCHWENDENER when he seeks to show that the lichen is not a distinct individual, nor a case of commensalism, but that it is merely a fungus living at the

Ueber die Algentypen der Flechtengonidien, Basel, 1869.

Quoted from *Sach's Text-Book of Botany*, Oxford, 2nd English Edition by VINES, 1882, pp. 328—329.

expense of plants, which on account of their diminutive size are completely enveloped by their parasite.

In defence of his theory, SCHWENDENER marshalled his results together in 1873¹. In this essay he merely re-states his facts, and answers a few objections. The evidences in support of the theory of parasitism brought forward are:—

It has never been demonstrated that a genetical relationship exists between the gonidia and the hyphæ. FRIES² has stated that he observed the hyphal ends in some cases to swell, and to become abstricted to form the gonidia, but he does not give sufficiently trustworthy evidence by noting the cases in which these phenomena took place; his statements may thus be due to errors of observation, or to misinterpretation of structure; but MÜLLER³ has stated that he has observed the formation of gonidia from the hyphæ in the case of *Synalissa*; he holds that SCHWENDENER's views do not apply to the *Omphalariaceæ* or for the *Glæolichenes* (Fries), and that in the rest of the lichens the gonidia originate from the hyphæ, but thereafter multiply independently. The experimental researches of REESS⁴ resulted in the production of a lichen through the cultivation of the spores of *Collema* on *Nostoc*, and MÜLLER was therefore obliged to overcome an insuperable difficulty in support of his views. This he did in a very plausible manner, by stating that *Collema* is a dimorphic plant, *i.e.*, one which exhibits two phases of structure in its growth and development. He says:—1°. That in its perfect state it produces hyphæ and fructifies, but that it is also represented by a secondary condition, known as *Nostoc*, which never bears hyphæ, nor apothecia. 2°. That *Nostoc* never reaches the condition of *Collema* until it is penetrated by a hypha derived from a spore or from root hairs, through what he terms a “vegetative copulation” of the hyphæ with the gonidia. 3°. That *Collema*, or the perfect condition of the plant, is generally reproduced by means of soredia, but that spore germination may also take place, and is always heralded by the development of the *Nostoc* stage; the structure can then produce apothecia through the impregnation of the gonidial filaments by the spore hyphæ. 4°. That the spores and gonidial filaments are mutually interdependent in the production of the fructification; that is, that the spores alone are incapable of producing a thallus, and the gonidial elements cannot produce apothecia without the intervention of the spore filaments.

MÜLLER goes still further, and states that the heteromerous lichens are somewhat similarly constituted. He points to the abundant lichens of the higher Alps where *Ascomycetes* are absent and *Alge* but rare, as natural protests to a theory which advocates the persistence of a group of plants entirely dependent upon what he looks at as a “fortuitous parasitism.”

¹*Die Flechten als Parasiten der Algen, Verhandl. der Naturf. Gesellsch. in Basel*, 1873, p. 527.

²*Lichenographia Scandinavica*, Upsala, 1871.

³*Flora*, 1872, pp. 90—93.

⁴*Ueber Entstehung der Flechte Collema glaucescens, Monatsber. der königl. Akad. der Wiss., Berlin*, 1871, p. 523.

The synthetical experiments of REESS, undoubtedly add great weight to SCHWENDENER's doctrine; he says¹:—"So soon as a germinating filament of a spore of a heteromerous lichen, or indeed one of its lateral branches, comes in contact with an alga of the species which plays the part of gonidia-former in the thallus of the lichen, it becomes attached on the surface of the alga, growing thereupon to a greater or less extent. The first result of the adhesion is more intense growth and increase of the number of hypha-branches, which partly in their turn again become attached to algæ, and also give off lateral branches, so that ultimately the alga or algal-colony which has come into contact with the germinating filaments, becomes completely encompassed by hyphæ."

"Though, then, I have not yet succeeded in producing a perfect heteromerous lichen thallus from its component elements, I still think I am perfectly justified in affirming that the results of my cultures are alone explicable by assuming the double nature of lichens; so that from the upholders of the organic individuality of the heteromerous lichen all arguments in its affirmation are equally taken away in an experimental way as has been previously done by SCHWENDENER in an anatomical way."

In 1873 BORNET published the results of his extended observations on sixty genera of lichens, in an elaborate memoir.² The evidence which he brings forward fully justifies his conclusions in favour of SCHWENDENER, and shows most indubitably that:—1°. The relations of the gonidia to the hyphæ are of such a nature that a genetical connection between them is quite impossible. 2°. That every gonidial element which has hitherto come under his observation, may be referred to some known group amongst the *Algæ*; this statement corroborates SCHWENDENER's observation. 3°. That the theory of parasitism is probably true, as it is the only satisfactory and sufficient explanation of the facts of the case.

BORNET arrived at these conclusions through a careful study of the forms of lichens, as well as by synthetical experiments. He showed that the gonidia never originate from the hyphæ, but that they do unite with the hyphæ subsequently; this is due to the parasitic habit of the fungus, which, in victimising the algal cell, even penetrates through its outer wall, and sets up pathological changes which at first stimulate the cell to increased activity, and are manifested in a thickening of its envelope, and an alteration of its protoplasmic contents which become pale and colourless; the wall finally shrinks, and the cell is thus destroyed. In *Synalissa* he has depicted these occurrences in evidence of the fact that the hyphæ do not give rise to the gonidia³; and he has stated that in *Synalissa conferta* he has observed some of the gonidial cells (referable in this case to *Glæocapsa*, and which have not suffered too much from

¹A Further Résumé of Recent Observations on the Gonidia Question, by W. ARCHER, *Q.J.M.S.*, New Series, Vol. xiv, p. 138.

²Recherches sur les Gonidies des Lichens, *Ann. des Sc. Nat.*, Paris, 1873, 5° Sér., pp. 45—110.

³*Op. cit.*, Pl. 16, Figs 1—3.

the destructiveness of the parasitic hyphæ) undergoing their ordinary course of algal development. Thus it appears that MÜLLER's view with regard to the connection of the gonidia and hyphæ in *Synalissa*, does not indicate a genetical relationship, but merely affords testimony in support of the theory of parasitism.

BORNET has noted, that when the algal elements are unicellular, the changes produced in them are not so well marked as when they are filamentous and composed of many cells; and that the quantity of algal elements which obtain in each individual case is directly proportionate to the activity of the hyphal tissue. As that tissue lives at the expense of the alga, and derives nourishment from it, it is clear that it must thrive best of all where there is the largest gonidial area; and such is the case.

The external shape of the lichen thallus is very largely dependent upon the growth of the hyphal tissue. In *Ephebe Synalissa*, the germinating filament of the spore is equally distributed throughout the alga, and its form therefore remains undisturbed; in *Synalissa conferta* the hyphæ take parallel courses and determine its cylindrical form. *Omphalaria* is fan-shaped on account of the radial disposition of its hyphæ, and *Collema* becomes lobed. In all these cases the gonidial elements take but a subordinate place; they are usually enveloped in the hyphal tissue.

Dead gonidial cells are by no means uncommon in the deeper portions of the lichen thallus; and all stages of abnormal conditions from the hypertrophied cell to the atrophied remains of others, may be found. It happens too, that widely different forms of algæ, e.g., phycchromaceous and chlorophyllaceous, occur associated together within the same lichen thallus; and that conversely, similar forms of *Algæ* are found in totally distinct lichens. All these facts are readily accounted for by the theory of parasitism.

In his syntheses, BORNET cultivated the spores of *Parmelia parietina* upon *Protococcus*, and found that after the fifteenth day numerous hyphæ were developed which attached themselves to the cells of the *Protococcus* whenever they came into contact with them. He found also that some lichens, such as *Pannaria triptophylla*, may take up the cells of other *Algæ* into their thallus, and thus display more than one kind of gonidial element, but that he has repeatedly tried to substitute *Trentepohlia* for *Protococcus* without success.

The effect of prolonged moisture is detrimental to the life of the lichen, as such; and BORNET admits, that in this particular, the gonidial elements are different from ordinary *Algæ*; this variation in their behaviour is probably due to their abnormal situation within the lichen thallus. If the thallus is immersed in water for some time, the hyphal portion decays; but some of the gonidia are freed, and were first observed by FAMINTZIN and BARANETSKY to produce *zoospores*; this in itself is a strong argument in favour of SCHWENDENER, but the discoverers of the zoospores explained their development by considering such forms as

Nostoc, *Cystococcus*, *Polycoccus*, etc., as independent lichen gonidia endowed with a vegetative activity.

The hyphæ are very often destroyed by an excess of moisture, and when this happens the affected part of the thallus seems to be composed of the alga alone; and plants which have been discovered in this state, have sometimes been described as exhibiting dimorphism; such especially has been the case amongst the *Collemeæ*.

In Nov. 1873, TREUB¹ read a memoir, containing a complete history of lichenology from the time of TULASNE down to that date, and giving a series of original researches, all conclusive of the Schwendenerian theory. STAHL,² in 1877, succeeded in producing a lichen, from the spores and hymenial gonidia of *Endocarpon pusillum*, which developed perithecia and spermogonia. He also discovered peculiar carpogonia in certain forms. These consist of filamentous structures which obtains as a close coil within the deeper tissues of the thallus; to this coiled body he gives the name *ascogonium*; the filament passes upwards from the ascogonium to project externally as the *trichogyne*. Fertilisation of the carpogonium is effected by means of spermatia which are produced in spermogonia, and which, on their dissemination, come into contact with the trichogyne. Absorption of the cell walls then takes place in this region, whereby the contents of at least one of the spermatia finds access to the carpogonium, and fertilisation is thus accomplished. The result is, that the ascogonium develops into an apothecium; its asci are formed from the ascogonium proper, and its paraphyses from the subjacent hyphal tissue. Thus it appears that the entire structure results from a development of the fungal portion of the lichen thallus, and this is in perfect harmony with the doctrine of SCHWENDENER.

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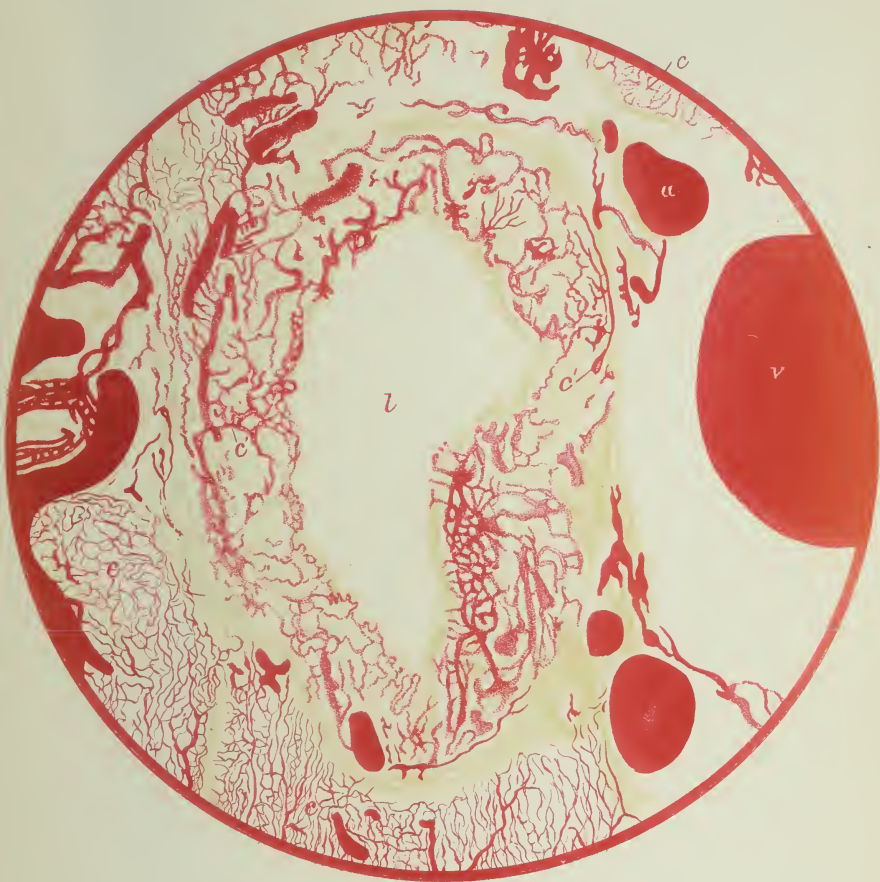
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¹ *Onderzoekingen over de Natuur der Lichenen*, Leiden, Nov. 22, 1873.

² *Beiträge zur Entwicklungsgeschichte der Flechten*, i, ii, 1877.

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del. ad nat.

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V. S. HUMAN PANCREAS.

Injected Carmine.

X 65.

THE PANCREAS.

T. S. OF HUMAN PANCREAS.

Injected Carmine.

× 65 diameters.

α Artery, v. Vein, l. Lumen of Large Duct, c. Capillaries of Alveoli, c'. Capillaries of Duct.

Etymology.—See Ante., p. 205.

DESCRIPTION.

THE BLOOD-VASCULAR, LYMPHATIC, AND NERVOUS SYSTEMS OF THE PANCREAS.—*The blood-vessels* enter the pancreas from various parts; the arteries proceed to it as branches of the splenic, superior and inferior pancreatico-duodenal rami of the hepatic, and superior mesenteric. Ramifications from these arteries are distributed throughout the gland amidst its connective tissue framework, until repeated division resolves them into a dense but uniform network of capillaries which closely surround the ducts and alveoli. The relations of these vessels to the connective tissue framework and gland-substance of the organ, are well shown in the illustration, which is an exact representation of a section taken from a well-injected specimen. The arterial system passes by means of the capillaries into the venous system, and the blood is conveyed away from the gland by means of the splenic and superior mesenteric veins.

The Lymphatic System.—According to BOLL¹ the lymphatic system of the salivary glands finds expression in a partial circumalveolar cavitary portion and many clefts, which lie between the capillary blood-vessels and the gland substance of the alveoli; from these numerous lymphatics arise, and form a plexus in the interlobular septa of connective tissue. In the pancreas the lymphatics are distributed in a manner which is essentially similar to that just recorded. Large lymph vessels furnished with valves, branch through the interlobar and interlobular connective tissue; these pass into clefts and sinuses, which are lined with endothelial plates, are situated between the intralobular lamellæ of connective tissue, and partially invest the alveoli (KLEIN)².

The Nervous System takes its origin from the solar plexus; the fibres in passing through the organ, do so alongside of the blood-vessels and lymphatics. According to PFLÜGER³ their ultimate fibrils end within the gland-cells themselves, as in the case of the salivary glands, but much doubt has been thrown upon the correctness of his statements by subsequent workers, who have failed to recognise what he has even carefully drawn. Many of the nerves terminate in Pacinian bodies.⁴

¹*Archiv für mikroskopische Anatomie*, Bonn, Bd. v.

²*Atlas of Histology*, London, 1880, p. 224.

³*Archiv für mikroskopische Anatomie*, Bonn, Bd. v; Article *Salivary Glands*, Stricker's *Handbook*.

⁴See this Journal, p. 206

THE DEVELOPMENT OF THE PANCREAS.

The present state of our knowledge of the mode of origin and growth of the pancreas, shows that throughout the *Vertebrata*, with the exception of *Amphioxus* and the *Ascidioidea*, its development is very constant. In some cyclostomatous fishes and *Teleostei* it is absent; and in *Petromyzon* and most of the *Teleostei* it is but ill-formed and reduced. In the *Elasmobranchii* and the higher *Vertebrata* it takes its origin as a hollow budding of the hypoblast, nearly opposite to, but somewhat behind, the primitive liver; it assumes the shape of an inverted funnel, the expanded dorsal portion of which grows out into a number of cæcal tubes, and these lie apposed to one another in the midst of the surrounding mesoblastic tissue of the body. The further growth of the diverticula is manifested in their elongation and branching, and whilst these changes are going on, the blood-vessels, lymphatics, and nerves of the organ grow into the connective tissue, and the whole of these structures combine, and result in the production of a solid glandular body, which eventually takes its position in the mesenteric folds at the dorsal part of the digestive tract. The funnel-shaped origin of the organ becomes reduced to a duct which places its canalicular system in communication with the duodenum, and is known as the canal of WIRSUNG (BALFOUR).

METHODS OF PREPARATION.

The section from which the illustration was taken, was prepared from a specimen obtained out of a fully formed still-born human infant. The carmine mass was injected through the aorta, and the entire circulatory system of the body fully injected; this is the best method of injecting the pancreas. It is obvious that if the organ be injected alone in the adult animal, a perfect injection would be attended with extreme difficulties, on account of the number of blood-vessels which would have to be ligatured in order to prevent a great escape of the injecting fluid.

In demonstrating the structure of the pancreas, and of all other glandular bodies, two methods of preparation are requisite, viz., staining, and injecting. The methods of staining are specially adapted to the exhibition of the connective tissue framework, and the epithelial elements of the gland alveoli and ducts; the exact relations of the alveoli to the ducts, is a matter which still requires investigation, and can only be arrived at through the processes of staining the tissues or of examining them in the fresh condition. The method of injection ought only to be applied to the vascular system, and in that case it is advisable to use a permanent colour in a transparent vehicle as the injecting mass. Soluble cold injections are apt to produce illusory effects (especially when they are forced through the pancreatic duct and its canalicular system) by staining the tissues around them to a slight extent. It is easy to understand how such a fluid would enter the alveoli, stain the clear substance of their lumina and even penetrate into the intercellular cement substance and dye it; and there can be no doubt that when SAVIOTTI injected a solution of Brucke's blue through the

system of ducts his results were vitiated in this way, and he made an admirable drawing of canals which do not exist.

In the study of the blood vessels of the pancreas, a carmine mass should be used, because it is permanent, and when supported in gelatine confines itself to the blood-vessels. The injection should be forced through the aorta, as soon as the body of the animal has reached a uniform temperature of about 40° C. through immersion in warm water. The external appearance of the organ will indicate when it is sufficiently injected. The body should be removed into cold water to permit the gelatine to solidify, and the organ may then be excised and prepared for cutting by being hardened.

CARMINE AND GELATINE MASS.—The preparation invented by Dr. CARTER, of Leamington, is the best for the purpose of injecting blood-vessels with a red material. It is prepared thus :—

Carmine (pure)	60 grains
Liq. ammon. fort. (B. P.)	120 minims.
Glacial acetic acid	86 minims.
Gelatine solution (gelatine 1, water 6 parts)	2 ounces.
Distilled water	1½ ounces.

(A). Dissolve the carmine in the ammonia and water; if necessary the solution may be accelerated by a gentle heat; filter. To the filtrate add 1½ ounces of the hot gelatine solution, and mix it thoroughly. (B). To the remaining ½ ounce of hot gelatine solution add the acetic acid. Pour B into A by dropping whilst stirring the whole fluid. The effect of the acid is to precipitate the carmine, which is then caught in the gelatine, and prevented from forming coarse aggregations, and this prevents a diffusion of the colour through the walls of the capillary blood-vessels.

HARDENING THE INJECTED PANCREAS. 1°. As soon as the injection has solidified within the blood-vessels, the organ may be cut into small pieces, about half-inch square and hardened first in a 50 per cent. solution of rectified spirit, to which one per cent. of hydrochloric acid has been added, then in pure rectified spirit, and finally in absolute alcohol.

2°. Small pieces placed in good methylated spirit which should be changed once a day for the first three days, will be found thoroughly well hardened after about ten days. This method was used in the preparation of the specimen from which the illustration was taken, and is certainly quite as effective as the first mentioned process.

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A. det. ad nat.

West, Newman & Co. lith.

DIABASE.
Corstorphine Hill, Edinburgh.
X 25.

DIABASE.

South Quarry, Corstorphine Hill, Edinburgh.

× 25 diameters.

Etymology.—DI'A-BASE, n. [Fr. *diabase*, from Gr. *διάβασις*, a crossing or passing over, from *διαβαίνειν*, from *δια*, through, and *βαίνειν*, to step, to pass;—so termed by BRONGNIART because he considered it to be a passage over to *Diorite*].

EXPLANATION OF PLATE.

The greater portion of the field is occupied by a large pale pinkish crystal of augite, which exhibits numerous cracks, and encloses many grey crystals of felspar. Two greenish patches may be observed within the augite; the larger of these is evidently the result of decomposition, the so-called viridite, and is lodged in a cavity within the augite; the smaller patch seems to shade off into the augite itself, it appears to be perfectly fresh, and may, therefore, represent a mere variation in the colour of the crystalline mass. All the greyish parts of the field show the forms taken by the felspar; some are rudely striated and with clear outlines, whilst others show signs of decay and kaolinisation. The cloudy grey which immediately surrounds the black crystals of titaniferous iron, is partially due to particles of thoroughly broken down felspar; it is attributed by GEIKIE to a decomposition of the iron, and, therefore, said to be leucoxene. One of the crystals of iron shows a contiguous brownish patch,—a linionitic discoloration. The greenish masses which are intercrystalline in location, are decomposition products of doubtful constitution; they may be termed viridite. Tufts, threads, and streaks of brownish matter, evidently some hydrous form of iron, are intercalated amongst similar structures within the green matter, which also lodges prismatic, hexagonal, and acicular clear forms of apatite.

DESCRIPTION.

Corstorphine Hill is an eminence situated within three miles of the town of Edinburgh. It is formed of a mass of igneous material, which bears evidences of its having been intruded, and deeply intruded, amongst the surrounding calciferous sandstone series, and subsequently

laid bare through denudation and glaciation. The whole of the area which it occupies is replete with interest to the field geologist. On the brow of the hill, which overhangs one of its quarries, unmistakable records occur of a past glacial epoch in the characteristic striation of the rock at its exposed surface. Thither GEIKIE resorted each year to tell the story of how SIR JAMES HALL in times past tried to puzzle out the origin of those striæ, with which every geologist is now familiar as the result of the gigantic action of ice, and how he attributed it to the influence of great waves of water "let loose by means of earthquakes, and that these Atlantic waves had spread over the country, carrying with them stones, earth, etc., and had striated the rocks on Corstorphine Hill and elsewhere in this way." The nature of the striation and its prevailing direction throughout the district, both show that one of the agents which revealed the igneous rock of Corstorphine, was an immense glacier.

The rock itself is most interesting, especially to the mineralogist who seeks after choice specimens of calcite, Prehnite, and pectolite, veins and crystals of which abound in its matrix. Quartz also, of the beautiful amethystine variety, is by no means uncommon; not, however, as an original constituent. Nor is it devoid of attraction to the geological philosopher; an examination of it *en masse* shows that it owes its origin to an intrusion from a mass which was probably injected into the crust of the earth during the carboniferous period. It also points out peculiarities in the segregation of the mineral constituents which have followed the law of gravitation in the accumulation of the heavier elements towards the lowest portion; for the rock, even to the naked eye, shows a division into a coarsely and more finely granitoid condition, and these pass by gradual transitions into one another. The coarse variety occurs below the finer portion, and may easily be seen to contain larger patches of green matter and augite, and less felspar than the latter. SCROPE¹ has pointed out that such things do occur in modern lava flows, where a separation of the ingredients takes place in accordance with their respective gravities, and GEIKIE² has adduced evidence, in the case of the pikrite of Blackburn Quarry, near Bathgate, that SCROPE's observations may be extended, and embrace the rocks of the Palæozoic age. Here, it becomes interesting to know that an *intrusive mass* has behaved in the same way.

Microscopical investigation shows in a manner at once decisive, that what the eye was barely able to discriminate is not only correct, but it adds very materially to a right interpretation of the structure of the rock by bringing into view its entire constituents, and, moreover, makes what was only vaguely ascertained, exactly understood. In the detection of the heavier ingredients in larger forms and proportions in the coarser texture it supports the evidence of the naked eye; but what is of far greater value, it reveals that the mineral constituents are all thoroughly crystallised, and that they are not bound together by a glassy substance, as in the case of rocks which have cooled

¹ *Volcanos*, London, 1872.

² *Trans. Roy. Soc.*, Edinburgh, 1879, Vol. xxix, p. 507.

at the surface of the earth, as in lava flows, *e.g.*, basalt; nor by a devitrified magma, as in intruded masses which cool slowly near the surface of the earth, as in the intrusive masses known as dolerites; but that they are absolutely crystalline, and point to a solidification of the mass at a great depth beneath the earth's surface, and therefore under an enormous pressure. Wherever interstitial matter occurs in the rock, it shows that it is a product of decomposition of some of its original component minerals.

THE GENERAL ARRANGEMENT OF THE MINERAL CONSTITUENTS.—In order of quantitative importance the felspar claims attention first. In both the coarse and fine varieties of the rock it forms aggregate masses from which individual prisms project in all directions and form a sort of irregular meshwork. In the coarse these prisms are larger than in the fine variety. Next in abundance comes the augite in very large dirty pinkish crystals which chiefly wrap up the irregular reticulum of grey felspar; under a low power of the microscope even, it is difficult to find one of such small dimensions as to come entirely within the field of view. The crystal depicted in the illustration is almost entire; it is seen to enclose many isolated felspar prisms. In both varieties the augite is equally well developed, but it occurs in relatively larger quantity in the coarser texture. The green decomposition product (viridite), obtains in larger patches in the coarse than in the fine rock, it is also more largely diffused, and its areas are more or less irregularly defined; in the finer rock the contours which it takes are occasionally six sided. The irregular patches often include projections and isolated prisms of grey felspar, and the clear prisms and needles of apatite are almost universally lodged within its boundaries. The iron is titaniferous; it occurs in form of large broken plates and well defined hexagonal forms. These do not occupy any definite positions but seem to be included at random throughout the field as intercrystalline groups amongst the felspar and green matter. It occurs in larger groups in the coarser than in the finer rock texture. Included between the groups, occasional crystals of iron pyrites may be detected by their metallic flash when reflected light is brought to bear upon them and specks of this mineral are commonly associated with the titaniferous crystals. I have not observed any magnetite. Limonitic, and more rarely hæmatitic discolorations, sometimes edge some of the iron crystals; and in much decayed specimens a yellowish brown fibrous product may be noticed holding together the remnants of disintegrated felspar in the green products. The apatite occurs largely in the coarse, and but sparingly in the fine variety. Unless otherwise noted, the several component minerals are precisely similar in both varieties.

From what has been stated, it may be gathered that the coarse variety of the rock owes its appearance to the development of large blebs of green matter contrasting strongly with the huge dark glancing crystals of augite, and the networks of felspar prisms, which are here large in size but in relatively smaller quantity than in the fine variety. The latter, on the other hand, is formed of a large number of smaller felspar crystals, and the augite, although it occurs in large forms, is com-

pletely pervaded and chequered by these crystals; the green matter too, obtains only in small patches, so that to the naked eye the rock assumes a uniform admixture of ingredients. No interstitial cement substance of any kind, either vitreous nor microfelsitic, occurs in either variety of the rock.

THE SPECIAL CHARACTERS OF THE MINERAL CONSTITUENTS.—THE FELSPAR. Under a power of about 25 diameters the greyish crystals of felspar show an indistinct striation due to the linear aggegregation of kaolinised particles. In external form their outlines are pretty well defined in the isolated crystals, and in the open meshwork; in the aggregate masses they are intimately blended together, and the alteration has taken place to such an extent that the whole assumes an amorphous granular aspect with only faint indications of its having been composed of many crystals. In very thin sections a kind of obscure cross hatching may be noticed, and the material simulates orthoclase, but there can be no doubt from the general disposition and form of many of the well-marked examples that it is a triclinic felspar; and reasoning from analogy, I am inclined to call it oligoclase.¹ A high power shows that the entire substance of the felspar has undergone profound changes; it is completely reduced to a kaolin, with the exception of small clear spots here and there, which may represent traces of the original fresh matrix of the crystal, these are brought out by the use of polarised light. Under fully crossed Nicols the striation of the prisms becomes more manifest, the masses of aggregate crystals are individualised; and some of them, especially in the coarse variety, show indications of bands of colour and twin lamellation.

THE AUGITE is of a dirty pinkish colour, and occurs in crystals of very large size. With a simple lens, or with the naked eye even, eight-sided forms may be distinguished; but when the microscope is brought to bear on these it will be found that their edges are very irregular, although good angles may be observed in almost every case; this is due to the interference of the felspar network, around which the augite must have crystallised, and which is now found intruded and enclosed within it. The crystals exhibit numerous cracks, which are chiefly due to the mechanical methods used in their preparation as sections for the microscope. Their edges are always sharply defined, and they do not exhibit any fissures along which changes have taken place, and which so very often occurs in this mineral within diabases. Under a high power (400 diameters) nothing noteworthy is revealed, except of a negative value. Fluid cavities and endomorphs of iron are only of exceptional occurrence. Cavities of large size, filled with a green alteration product, are very rare; one of these has been figured in the illustration, and sometimes portions of the crystalline mass vary in colour to a greenish hue.

THE VIRIDITE.—I have chosen to apply this term to the green decomposition products which have already been alluded to above, on account of their obscure nature. Their ill-defined six-sided outlines in the fine

¹ See J. F. E. DATHE, *Mik. Unters. ü. Diabase*, *Zeits. d. d. Geol. Gesellsch.*, 1874, Bd. xxvi, pp. 1, *et seq.*

variety, and their occurrence in large quantity (due to gravitation of the mineral of which they are pseudomorphs, to the lower zone of the intrusive bed) in the coarser form, seem to indicate that the mineral which occupied their place, was olivine. The olivine was probably decomposed and almost entirely carried away, or the results of decomposition combined with other secondary constituents, and, may be, with broken down particles of the felspar and iron to form the viridite. Amongst the latter, projecting crystals of felspar may be seen; some of these are considerably decayed, and show a transition into a fibrous tufted material which sometimes occupies a large portion of the greenish area. Under a high power the green matter is resolved into a substance showing a matted fibrous structure, passing occasionally into a granular ground mass. Small particles of iron may often be found embedded within it. The clear crystals of apatite also occur almost exclusively here. Under crossed Nicols the viridite gives the characteristic aggregate polarisation which has been noted in the green material of pikrite.

THE TITANIFEROUS IRON, forms large plates and hexagons of well marked forms often aggregated into crystallographic groups, and associated with specks, and more rarely with large crystals of pyrite. Slight discolourations at the edges of some of the broken plates and crystals show that a limonitic (yellow) or hæmatitic (yellowish-red) change has effected the iron. In other cases the irregular lamellæ are surrounded by a cloudy whitish-grey material; and it may be noticed, that in very thin sections, the iron plates seem to be broken down into an aggregate of minute rods which lie apposed to one another in linear series forming parallel rows, and that the whitish substance fills up the interstices between these rods. GEIKIE considers this substance to be leucoxene, a product which results from the degeneration of titaniferous iron.

THE APATITE occurs in the usual form of pellucid prisms and needles, as in most igneous rocks. Its optical characters have been described in connection with the rocks, pikrite and dolerite¹. Beautiful examples of hexagonal sections are commonly met with in the green decomposition product in the coarser variety of the rock, in the finer rock it occurs but rarely.

It occasionally happens that some of the areas which are occupied normally by the green material, give place to other products of secondary derivation. The most frequent of these infiltrated ingredients is a whitish brown zeolite, exhibiting a finely striated structure; and wherever this occurs, it lodges many delicate clear prisms of apatite of the most perfect form. Similarly related to the original rock matrix are minute blebs of quartz, which, however, obtain only exceptionally.

¹See this journal, pp. 51, 53, 193.

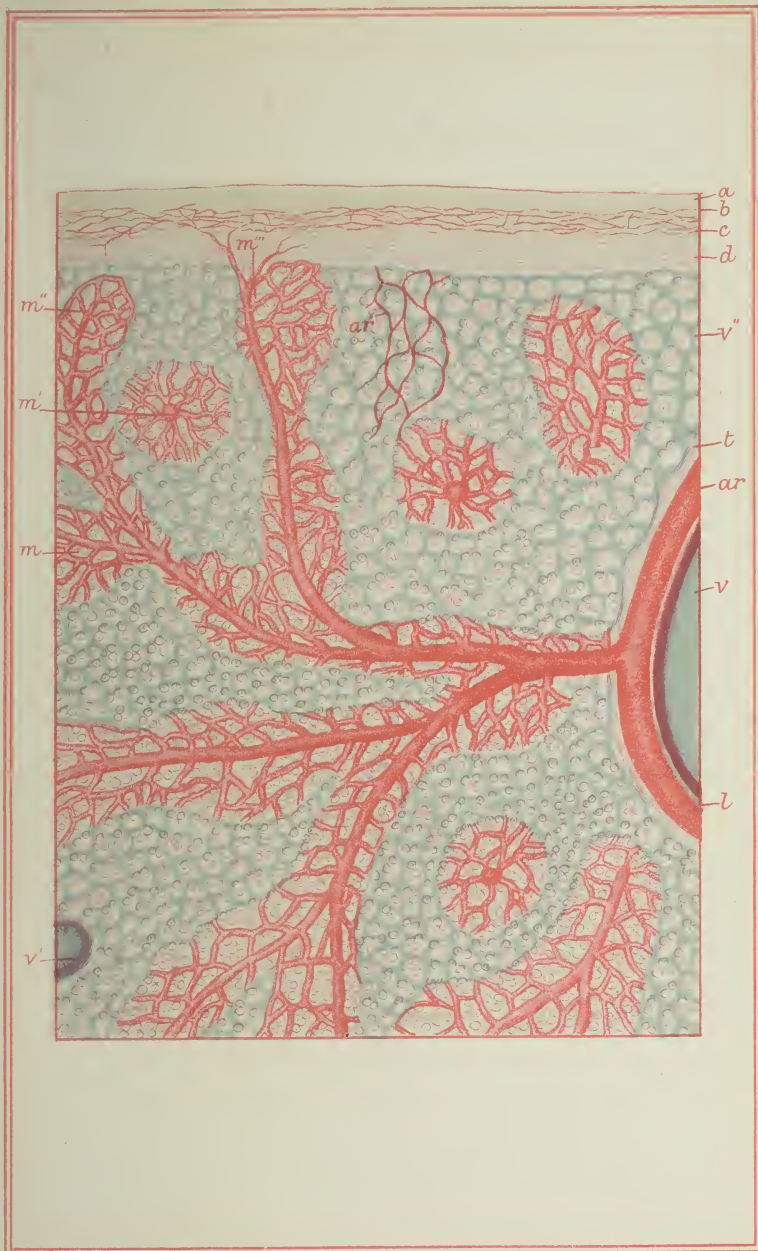
METHODS OF PREPARATION.

See this Journal, pp. 54—61.

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ad. ad. nat.

West, Newman & Co. lith.

THE SPLEEN.
Diagrammatic Drawing.

THE SPLEEN.

T. S. OF HUMAN SPLEEN.

Injected Carmine and Stained with Hæmatoxylin.

a. Endothelial Investment, *b.* Delicate Serous Layer of Connective Tissue with numerous Elastic Networks, *c.* Feltwork of Trabeculæ of Connective Tissue with Blood-vessels and Nerves, *d.* Layer of Unstriated Muscle, *t.* Trabecula of Connective Tissue ensheathing Artery (*ar*), Vein (*v*), and Lymphatics (*l*), *v.* T.S. of Vein surrounded by Connective Tissue, *v'.* Venous Sinuses of Pulp. The rounded purple elements represent the cells of the pulp and of the Malpighian corpuscles. *m.* Malpighian Corpuscle, *m'.* T.S. of Malpighian Corpuscle with centrally situated Artery, *m''.* Malpighian Corpuscle in which the Artery is seen to terminate in a Capillary Network, *m'''.* Malpighian Corpuscle in which its Artery is shown passing out into the Pulp Tissue, and anastomosing with the Vessels of the Framework, etc., *ar'.* Arteries of Pulp Tissue.

Etymology.—SPLEEN, *n.* [Lat. *splen*, Gr. *σπλίγν*, the milt or spleen]. (*Anatomy*).—"The spleen is a soft highly vascular and easily distensible organ, of a dark bluish or purplish grey colour. It is situated in the left hypo-chondrium, between the cardiac end of the stomach and the diaphragm. It is the largest of the organs termed ductless glands."¹ The ancients supposed it to be the seat of anger and melancholy.

DESCRIPTION.

ON THE MINUTE STRUCTURE OF THE SPLEEN.—An examination of sections with a low power of the microscope, is sufficient to show that the spleen, like all other glandular bodies, is built up of a framework and a gland substance or parenchyma, and that it differs widely from structures which are obviously concerned in the secretion of elements which are carried away by special ducts and channels, but approaches more nearly to those which are known as ductless glands, more especially the thymus and lymphatic glands.

THE FRAMEWORK consists of a relatively thick capsular investment, from which trabeculæ pass into the substance of the gland, and by ramifying and anastomosing in all directions form a dense network which supports the other elements of the organ.

(i). *The Capsule* may be examined in normal saline solution, from sections of the fresh tissue obtained with the use of a freezing microtome,

¹ QUAIN'S *Elements of Anatomy*, 8th Ed., Vol. ii, p. 397.

as well as in hardened and strained preparations. In either case it will be necessary to use a power of about 300 diameters. The free surface of the capsule if "silvered" will show clearly that it is lined by a layer of endothelial plates, which are essentially similar to those lining the peritoneum. Underneath this comes a band of delicate gelatinous connective tissue full of interlaced elastic fibrils; this is the serous layer, and it passes by gradual transitions into a much thicker zone of connective tissue, made up of white fibres and their corresponding corpuscles, which produce strands; and these latter unite to form a kind of densely interwoven highly vascular and nervous reticulum.

A large quantity of non-striated muscular fibres, somewhat like those which obtain in the tunica media of blood-vessels, are found in the capsule of the spleen, but their distribution varies in different animals. In most mammals they may be detected as plexuses in the deeper layers under the serosa, and may there be arranged as a superficial transverse and a deep longitudinal layer (KÖLLIKER²). They are particularly well developed in the spleen of the horse, pig and dog, and to a less extent in that of the sheep, and ox (BILLROTH³ KYBER⁴). In the ape, only a thin deeply situated longitudinal layer obtains (KLEIN⁵), and in man these are reduced to thin bundles arranged in plexuses (W. MÜLLER⁶).

(ii). *The Trabeculae* are inward prolongations of the connective tissue of the capsule. The blood-vessels which enter the organ in company with lymphatics and nerves, are enveloped in the tissue of the capsule which is thus tucked in at this part; but other trabeculae of various sizes enter the substance of the organ from all parts, as prolongations of its inner coat; they branch repeatedly, anastomose, and thus form a network which becomes continuous with the tissue which enters at the hilum. In form they vary very considerably; some are large and cylindrical, and merge directly into the more delicate tissue to be presently described; others are finer, more band-like, and may terminate by filamentous ends in the substance of the gland.

In histological structure, they consist chiefly of fibrous connective tissue largely intermixed with non-striped muscular fibres longitudinally disposed. KLEIN⁷ has observed that in the larger strands the muscular elements form longitudinal bundles, which belong, as it were, to the adventitia of the large blood-vessels which lie within the trabeculae; he has also detected unstriated muscle cells in even the finest of these.

The great elasticity which the organ possesses in virtue of the high development of these fibrous and muscular elements in its framework is undoubtedly of the highest importance in enabling it to withstand the sudden alterations in size to which it is often subjected.

The intertrabecular portion of the gland is occupied by adenoid connective tissue, arranged in peculiar ways; and admits of a two-fold

¹Stained with Silver nitrate, See this Journal, p. 136.

²*Handbuch der Gewebelehre des Menschen*, Leipzig, 1867.

³*Zeitschrift für Wiss. Zoologie*, Bd. xi.

⁴*Archiv. für Mikroskopische Anatomie*, Bd. vi.

⁵*Atlas of Histology*, London, 1880, p. 423.

⁶*Ueber d. fein. Bau der Milz*, 1865

⁷*Op. cit.*, p. 424.

division into a corpuscular portion, and the pulp. The adenoid tissues of each of these sections merge into each other on the one hand, and into the connective tissue of the trabecular system on the other.

THE GLAND SUBSTANCE of the spleen as has already been noted, finds expression in two groups of tissues which pass into one another, but are yet sufficiently distinct from each other to form a tolerably sharp line of demarcation.

(i). THE CORPUSCULAR ELEMENTS.—In stained sections of the spleen a moderately low power of the microscope (20 or 30 diameters) shows the gland substance in form of a uniformly granular tissue, partitioned off into areas by the trabeculæ, and here and there within these spaces there are portions, usually of sub-circular outlines, which seem to be formed of a more densely granular tissue; these are the so-called *Malpighian corpuscles*. The intervening uniform tissue is the pulp.

In well injected specimens, examined under a power of about 300 diameters, it will be found that these Malpighian corpuscles are formed of a retiform tissue, similar to that which obtains in lymph glands, viz., a honeycombed reticulum, with adnate endotheloid plates, each of which is furnished with a large oval flattened nucleus.¹ At its periphery this connective tissue is in direct continuity with the adenoid tissue which forms the delicate supporting structure of the pulp elements. It is, however, distinguishable from that tissue in being somewhat more densely reticulated. Towards the centre of the corpuscle the meshwork becomes comparatively lax (BUSK and HUXLEY²). In the meshes of the reticular network lie the lymphoid cell; each cell possesses one or two large spherical nuclei enveloped in a zone of clear protoplasm.

In the vast majority of instances the outlines of the Malpighian corpuscles are seen to be circular in sections; some of them are oval, and occasionally elongated forms which blend with one another may be detected. Towards the centre, usually in a somewhat eccentric position, the transverse section of an artery may be seen, and this has given rise to the interpretation that the Malpighian bodies are spherical or ovoid masses of adenoid tissue aggregated at intervals upon the arterial twigs of the gland. In reality, however, it has been shown by KYBER³ and others, that the splenic artery accompanied by the vein, enters the organ at its hilum and continues in the trabeculæ of the framework surrounded by their connective tissue and muscular elements; the vessels in this situation are surrounded by lymphatics, lymph, and interfascicular spaces; but the artery soon leaves the vein, to enter into the intertrabecular areas; here its adventitia become surrounded by a development of dense adenoid tissue cylindrically disposed and varying in amount from place to place. At some parts this adenoid mass is more largely developed on one side of the vessel

¹In order to observe this adenoid reticulum satisfactorily, it is advisable to cut sections from the fresh spleen, to agitate them well in a test tube of water, and thus to isolate the connective tissue from the other elements. Sections thus treated may be silvered, or otherwise stained, and mounted in any of the ordinary media.

²Sydenham Society's translation of KÖLLIKER's *Histology*.

³*Op. cit.*

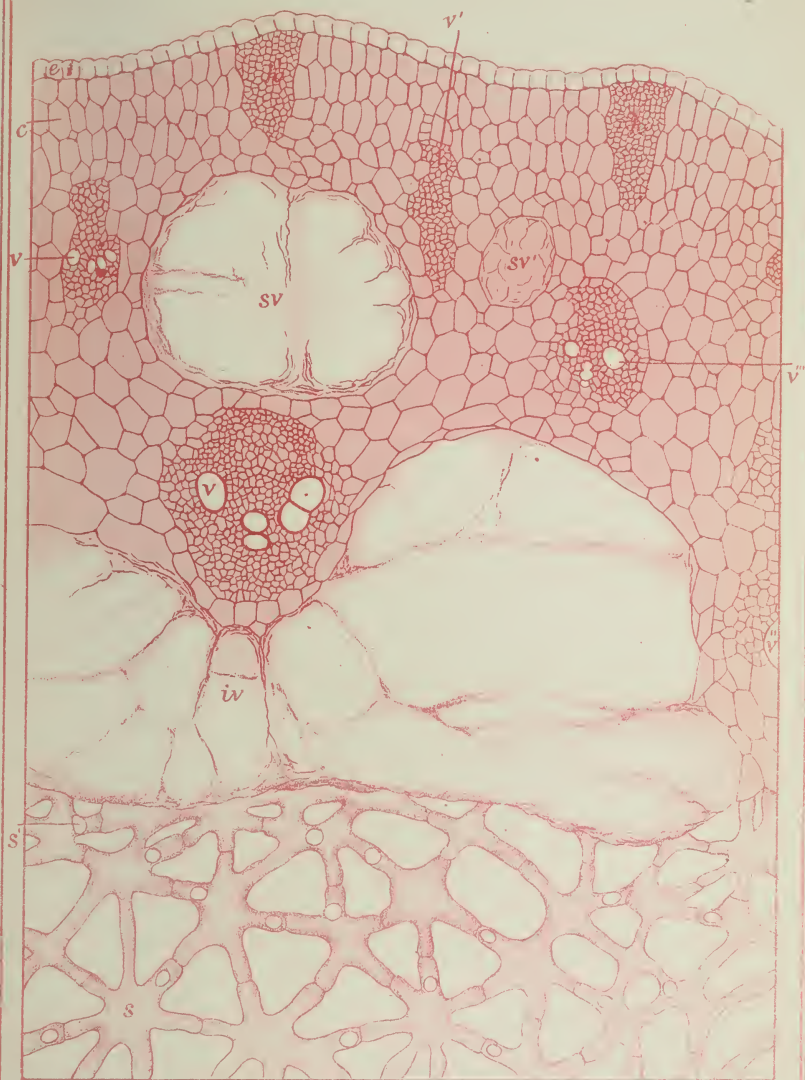
than on the other; it often becomes equally distributed, and occasionally forms a more or less spherical or ovoid aggregate, especially towards the periphery of the organ. Thus it is that when sections are examined, these cylinders give rise to circular or oval outlines, usually with eccentrically placed arterial sections, but these are sometimes centrally situated. These appearances are obviously dependent upon the direction in which the section has been made.

The central artery of the Malpighian corpuscle may terminate finally within the body itself, by becoming resolved into a network of capillaries, which open into the spaces of the pulp tissue. This may be readily recognised in an injected preparation of the spleen; there it may be seen that the tissue of the Malpighian corpuscle is not pervaded by the injected fluid, as is the case with the pulp tissue, but that on the contrary, it is supplied with a distinct capillary plexus. The artery need not, however, come to an end within the corpuscle; that it does not always do so may often be ascertained, especially towards the periphery of the organ, where the adenoid sheath may be occasionally noticed to cease abruptly, and the artery to emerge and enter on a further, but more limited distribution.

METHODS OF PREPARATION.

The best method of injecting the spleen with a gelatine mass, is to operate upon a small animal, and to inject the whole system through the aorta; the spleen should be carefully watched during the process which should be discontinued as soon as it becomes fully distended. Injections through the splenic artery may be resorted to in the case of the larger animals.

The processes employed in the preparation of injected and stained sections, have been fully described at pp. 85, 219, etc.



A. del. ad nat.

Wm. Morrison Sc. Lib.

JUNCUS COMMUNIS.

Variety Effusus.

T. S. of Stem, X 250

JUNCUS COMMUNIS.

VARIETY EFFUSUS.

Transverse Section of Stem.

× 250 diameters.

e. Epidermis, *h.* Hypodermis, *c.* Cortex, *v.* Vascular Bundle situated midway between Supra- and Infra-Vascular Areas of Delicate-Walled Tissue, *s.v.* and *i.v.*, *v.* Vascular Bundles of *v*-System, *v'*. Vascular Bundle situated between Adjoining Infra-Vascular Areas of Delicate-Walled Tissue, *v''*. Vascular Bundle of *v'*-System, *s.* Central Stellate Parenchyma, *s.* Scar of Branch of a Stellate Cell, which has been cut off, *s.v'*, Branch off *s.v.*

Eytymology.—JŪN'CUS, *n.* [Lat. *juncus*, rush]. (*Botany*).—A genus of plants belonging to the family *Juncaceæ* and the order *Liliifloræ*.

CŌM-MŪ'NIS, *a.* [O. Eng. *commun*, *commune*, Fr. *commun*, Pr. and Sp. *comun*, Pg. *commum*, It. *comune*, Lat. *communis*, from *com*, for *con*, a Latin preposition signifying *with* or *against*; used in composition as an inseparable prefix, for *com*, q.v., before all consonants except the labials *b*, *p*, and *m*. Before *l*, *con* or *com* is changed into *col*, as in *to collect*, from Lat. *colligere*, and before a vowel or *h*, the *n* or *m* is dropped, as in *to co-operate*, *to coalesce*, *to cohibit*, etc., and *munis*, ready to be of service, from *munus*, service, work. Ger. *gemein*, O. H. Ger. *gimeine*, Goth. *gamains*, A-S. *gemæn*, *gemæne*, are all allied to Lat. *communis*, common]. (WEBSTER).

EF-FŪ'SUS, [Lat. *effusus*, p.p. of *effundere*, effuse.] (*Botany*).—Spreading loosely, especially on one side, as an *effuse* inflorescence, LOUDON.

DESCRIPTION.

Juncus Communis, MEYER, is popularly known by the name soft rush, and exists in form of two varieties, which are described by HOOKER¹ as follows:—"Stems soft, pith continuous, perianth-segments lanceolate exceeding the obovoid retuse capsule, stamens 3."

¹*The Student's Flora of the British Islands*, London, 1878, 2nd Edition, p. 412.

“Moist places; ascends to 2,400 ft. in the Highlands; fl. July, Aug. *Tufts* circular, densely matted. *Stems* 1-3ft., sometimes $\frac{1}{4}$ in. diameter, green, very finely striate. *Cymes* very compound, variable in form and size. *Perianth* 1-10th— $\frac{1}{8}$ in. *Stamens* rarely 6. *Seeds* minute, yellow-brown.—DISTRIB. Europe, N. Africa., temp. Asia and America.”

“VAR. 1, *effusus* L. (sp.); cymes usually lax effuse, perianth olive-green, anthers oblong, capsule not mucronate.—VAR. 2, *conglomeratus*, L. (sp.); cymes usually dense subglobose, perianth tinged with brown, anthers longer linear, capsule mucronate.”

At page 865 of the English edition of LE MAOUT and DECAISNE'S Descriptive and Analytical Botany, the following two sentences occur, and are worthy of note here:—

“*Junceæ* inhabit damp meadows and swamps, or grassy and woody mountain regions; they are scarce on dry ground. They mostly grow in north temperate latitudes, and some species advance to both polar regions; they become rarer as we approach the equator. *Juncus* and *Luzula* are cosmopolitan, and are met with on the highest mountains of both worlds. *Prionium* is South African; *Rostkovia* inhabits the Maganellie lands [and New Zealand].”

“The properties of *Junceæ* are uninteresting. The fruit of *Juncus acutus*, baked and steeped in wine, is said to be a diuretic, and to stop menorrhagia, but it gives headaches. The rhizomes of *J. conglomeratus*, *effusus*, *glaucus*, and especially of *Luzula vernalis*, are popular diuretics in Central Europe. *J. glaucus* is cultivated by gardeners to make bands of. The Chinese use the pith of certain species for candle-wicks. [The farthing rushlight of England had a wick of rush pith].” Rush-candles are small tapers, made by stripping off most of the outer layers of the stem except a small thin zone which holds the pith together, and dipping it in tallow.

ON THE MINUTE STRUCTURE OF THE STEM IN *JUNCUS COMMUNIS*, VARIETY *EFFUSUS*.—On the General Arrangement of Parts.—The lithographed illustration, magnified 250 diameters, is an exact representation taken from a section which had been stained with a solution of carmine. Under a low power of the microscope (25 diameters), the boundary line of the section is seen to be sinuous. The ridges and their intervening depressions, give rise to the fine superficial striation of the stem structure. The external limiting layer is formed of a single row of cells, termed the *epidermis*. Underneath this comes the *cortical layer*; within this zone certain structures obtain, and are arranged in a characteristic manner. These may be described under the three following heads. (a). The *Hypodermal System*, consists of elongated triangular patches, in transverse section, developed at intervals, immediately beneath the epidermis of the ridge summits, and projecting inwards into the surrounding cortical parenchyma. (β). The *Intracortical System*, is constituted by areas of very large, delicate walled cells, which in transverse section present circular and compound

circular forms, and are entirely surrounded by the cortical parenchyma, except at the innermost part, where they are bounded by the central pith. In order to understand their relations to each other, it will be necessary to describe the next section. (γ). *The Fibro-Vascular System*.—The cortical parenchyma dips down towards the central pith at stated intervals to form a series of primary intrusions; in the peripheral focus of each of these papillæform projections, large closed fibro-vascular bundles are situated (v). Midway between the primary intrusions, the cortex forms smaller secondary eminences, in the midst of which smaller closed fibro-vascular bundles obtain. Immediately above the vascular bundles just noted, come parts of the intracortical system to which I have given the name *supra-vascular areas*; these areas are usually of circular or subcircular contours, and are completely surrounded by the parenchyma of the cortex. The development of the primary and secondary inward elevations of the cortex, gives rise to spaces of compound circular forms which lie beneath the system of fibro-vascular bundles, between them and the pith. These spaces are the parts allotted to another portion of the intracortical system, to which I have applied the name of *infra-vascular areas*; the cortical parenchyma bounds them above and on each side, but below they are directly superjacent to the medullary tissue. Of minor importance are smaller areas of a similar nature, which lie imbedded in the upper portion of the cortex, but always beneath the hypodermal zone; they are lateral with regard to the supra-vascular areas, and in their vicinity, small closed fibro-vascular bundles may be found.

The study of longitudinal sections shows, that the primary and secondary fibro-vascular bundles lie parallel with each other, and that the supra and infra-vascular areas take similar courses, but that the minor bundles and areas are offshoots from the larger ones. Thus, the division of these structures into systems, is quite in harmony with observed facts.

The whole of the central portion of the section is filled with a pith composed of a stellate parenchymatous tissue.

On the Special Structure of the Elements which Combine to form the Tissues of the Stem.—The study of transverse and longitudinal sections should be conducted under a power of at least 250 diameters.

(i). *The Epidermal System*, consists of a single layer of elongated cells with cubical outlines in transverse section; their external parietes coalesce and becomes cuticularised; their inner walls remain tolerably thick. Their protoplasmic contents are hyaline, and to a large extent absorbed, so that in sections which have been subjected to the action of alcohol and mounted in Canada balsam, they appear to be empty.

(ii). *The Cortex*.—(α). *The Hypodermal System* is developed in form of elongated parallel bands which lie immediately below the summits of the external ridges, and doubtless give rise to the striation of the stem. Its cells are in the form of thickened bast fibres, and combine to form longitudinal rods of collenchymatous tissue; several of them are filled with a granular proto-

plasm, which stains deeply in carmine. The cortical parenchyma, which consists of oblong cells of large size and filled with hyaline protoplasm, is situated between the hypodermal bands, and surrounds the other systems in the manner already indicated.

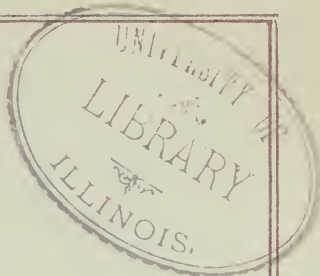
(β) *The Intra-cortical System* is composed of parallel, occasionally branched, longitudinal cylinders, formed of a tissue which seems to have resulted from the enormous enlargement of the cells of the cortical parenchyma. The cell walls are delicate, and in the fresh condition are filled with a hyaline protoplasm, the action of reagents causes these cells to collapse, and their cell-walls thus take on the character of networks of threads stretched across the areas, in slightly thick sections, however, some of the smaller areas may be noticed properly stained, and showing the original outlines of globose cells distended with cell-contents.

(γ) *The Fibro-Vascular System*.—The general arrangement of the bundles has already been described; they consist, as in all Monocotyledons, of closed systems.¹

(iii) *The Medulla*, consists of a pith composed of stellate parenchyma. The cells are in the form of star-shaped bodies, the rays from which join those of contiguous cells by transverse intermediate septa. In a transverse section these cells form a singularly beautiful pattern of a tolerably regular description; but in longitudinal sections, the rays, which are disposed lengthways, are of unequal lengths, and this regular stellate pattern is obscured. The cells are filled with a delicate granular protoplasm which becomes but faintly stained; their cell-walls however absorb the colouring matter more readily, and their outlines are thus clearly mapped. The intercellular spaces which originate through the characteristic development of this tissue, contain a few interspersed groups of acicular crystals which aggregate into irregular radiating accumulations.

The methods of preparation and of staining vegetable tissues, are fully described at pp. 14, 16, 85, etc.

¹See this journal, p. 29, *et seq.*



A. del. ad nat.

West, Newman & Co. imp.

SPLEEN OF CAT.
T. S. Stained Logwood.
X 65.

THE SPLEEN.

T. S. Spleen of Cat, stained Logwood.

× 65 diameters.

c. Capsular Connective Tissue, *p.* Pulp Tissue, *t.* Connective Tissue Trabecula, *v.* Vein. Two Malpighian corpuscles are shown, one of which exhibits the transverse section of an artery.

Etymology.—See this Journal, p. 227.

DESCRIPTION.¹

(ii). **THE PULP TISSUE.**—If a small piece of the pulp of a fresh spleen is teased out carefully and examined on a warm stage under a power of about 350 diameters, the characters of its cellular elements may be readily recognised. The dissociation of these elements shows:—(*a*). Lymphoid cells of many sizes; some of them possess one, others two or more well marked granular sub-spherical nuclei surrounded by a zone of clear protoplasm; they all exhibit amœboid movements (COHNHEIM²). (*β*). Cells of similar form, which include in their interior coloured blood corpuscles in various stages of disintegration, from well marked bodies, to mere granular aggregates of a yellowish-brown pigment. (*ν*) Endotheloid plates usually with one flattened nucleus, but there may be more than one nucleus, and the margins of the plates are produced into band-like or membranous processes. (*δ*) Spindle-shaped cells of very various forms.

If now a thin, well-hardened and well-stained section is examined under powers of from 3-500 diameters, it will be found that the endotheloid plates (*ν*) are combined to produce a delicate honey-combed network. In some of these cells, it has been noted by KÖLLIKER, KLEIN,³ and others, that the nucleus, which is commonly oval and flattened, becomes somewhat modified; it is beset with many bud-like processes, is often

¹Continued from p. 230.

²*Virchow's Archiv*, Bd. xxxiii, p. 311, etc.

³*Atlas of Histology*, p. 425.

lobed, and ultimately splits up into a number of small nuclei. These appearances are best seen in the spleen pulp of young animals, such as in man, the dog, pig, guinea-pig, rat, and mouse. The endotheloid cell-plates in virtue of the filamentous, band-like, and membranous processes which they possess, combine to form the reticular meshwork. Their variations in size and position cause corresponding diversities in the dimensions of the intercellular spaces, which range from $8-32\mu$ in diameter. Their substance is generally hyaline, but often contains patches of granular yellowish-brown pigment, and degenerated red blood-corpuscles. These appearances are by no means constant; they are best observed in the spleen of the pig, and in the abnormally congested condition of that organ in the human subject. (KLEIN.)¹

According to KLEIN¹ the cell plates show spherical or oval corpuscles, which are absolutely identical with the lymphoid corpuscles, attached to them by means of a longer or shorter stalk, or altogether free from them; he looks upon these as the result of a process of gemmation of the endotheloid cells.

The lymphoid cells of the pulp are precisely similar to those of ordinary lymph glands, such as those of the alimentary tract. They lie within the intercellular meshwork of the matrix, somewhat more loosely than their representatives in the Malpighian corpuscles.

Intervening between the lymphoid cells and endotheloid reticulum, spaces exist, which, under normal conditions are filled with blood. The endotheloid plates at intervals become so disposed as to give rise to pseudo-vascular channels, which open into the aforesaid spaces. These pseudo-vascular channels, or *cavernous veins* of BILLROTH, are formed by the peculiar apposition of the endotheloid plates, which become adpressed to form a liminary membranous expansion around a sinus; the processes of the cell-plates pass into the surrounding meshwork, and the sinus is lined by a delicate layer of elastic fibrils. Thus when a superficial view of the the structure is obtained, it appears to be composed of polyhedral cells; a transverse view, however, shows that it is in reality formed by the coalescence of the endotheloid cells to form a membranous coat with occasional stomata, and the elastic fibrillar support is manifested in form of a marginal rim of dots.

The venous sinuses thus constituted form plexuses in the pulp, and these are often arranged in tubular series, as in man and the ape; the intervening tissue thus becomes defined into areas,—the *intervascular tracts* of BILLROTH. The venous sinuses open directly into the veins which are situated within the trabecular connective tissue of the organ. Klein² has noticed that they cease to exist in the immediate vicinity of the Malpighian corpuscles, in the case of man and the ape.

The Blood-Vascular System.—The venous system of the spleen commences in the intercellular spaces of the pulp, which open into the venous sinus just described; these, in their turn, empty themselves into

¹*Op cit.*, p. 426

²*Op. cit.*, p. 427.

the venous trunks which are situated within the trabecular strands which pervade the whole organ. In addition to this venous system, the pulp possesses arteries; some of these are continuations of the vessels which ramify through the Malpighian corpuscles. It may be noted here, that some of the arteries of the Malpighian corpuscles come to terminations within those bodies, and that preliminary to such ending, they become invested in a layer of concentrically arranged endotheloid plates, between which a few lymphoid corpuscles obtain. Other arteries, which, however, are entirely independent of the vessels of the Malpighian corpuscles, ramify and anastomose in the pulp. KLEIN¹ states that in the cases of man, the ape, and the pig, these vessels become ensheathed in concentrically disposed endotheloid plates, and are to be regarded as small arteries, and not as capillaries with a special *capillary sheath* as suggested by SCHWEIGGER-SEIDEL and others.

Lastly, it has been stated by BILLROTH, GROSSE, SASSE, KYBER, and others, that the intervascular tracts of the pulp, exhibit capillary blood-vessels which connect the capillaries of the Malpighian corpuscles with the venous sinuses of the pulp; but this statement has been altogether denied by W. MÜLLER, FREY, KLEIN, and others, who have shown that the intercommunication of the two systems is effected through the spaces of the honeycombed matrix, which intervenes between the Malpighian corpuscles and the venous sinuses. Our own observations tend to support the latter conclusion.

The peculiarly intimate relationship into which the blood is brought with the cells of the pulp tissue, and the consequent appearances of the cells of that tissue, have led histologists to conclude that one of the functions of the spleen, is to destroy the red blood-corpuscles. The pulp-tissue is also evidently the elaborator of leucocytes; and according to the recent researches of BIZZAZERO and SALVIOLI, it is also the birth-place of coloured blood-corpuscles.

The Lymphatic System.—The researches of TOMSA² and KYBER³ have revealed a capsular plexus of lymphatics, which branch into the substance of the organ, either as closed vessels or in form of clefts; these produce plexuses within the trabeculæ or at their boundaries with the pulp tissue. A perivascular system composed either of tubular vessels or of anastomosing sinuses surrounds the arteries and communicates on the one hand with the trabecular plexuses, and on the other with the adenoid tissue of the Malpighian corpuscles, by means of clefts and lacunæ. The pulp tissue is devoid of lymphatics, except at the margins of the trabeculæ, and KYBER has shown that the perivascular and capsular systems communicate directly with each other in the hilum.

The Nerves of the spleen are derived from the solar plexus, they occur in form of non-medullated fibres near to the arterial branches. W. MÜLLER⁴ has stated, that they terminate in the so-called capillary sheaths of SCHWEIGGER-SEIDEL.

¹*Op. cit.*, p. 427.

²*Sitzungsber. d. k. Akad.*, Wien, Bd. xiv, Abth. I.

³*Arch. für mik. Anat.* Bd. viii, p. 568, *et seq.*

⁴*Ueber d. fein. Bau der Milz*, Leipzig, 1865.

METHODS OF PREPARATION.

HARDENING THE SPLEEN.—If the spleen of a cat or other newly-killed mammal is chosen, pieces about half-an-inch square should be hardened in Müller's fluid for a week, transferred to a solution of chromic acid and spirit for another week, and finally to rectified or good methylated spirit for a third week. Sections should be stained with logwood and mounted in Canada balsam or dammar solution. In the case of the human spleen, it is well to permit the pieces to remain in the chromic acid and spirit solution for two weeks, and then to transfer them to alcohol.

SILVER NITRATE INJECTION.—The blood-vessels should be washed out with distilled water, and thereafter injected with a quarter per cent. solution of silver nitrate. The tissues are then to be hardened in alcohol, and sections exposed to light in the usual way; they may thereafter be stained with logwood. Sections prepared in this manner show the endothelial outlines of the venous sinuses very clearly.

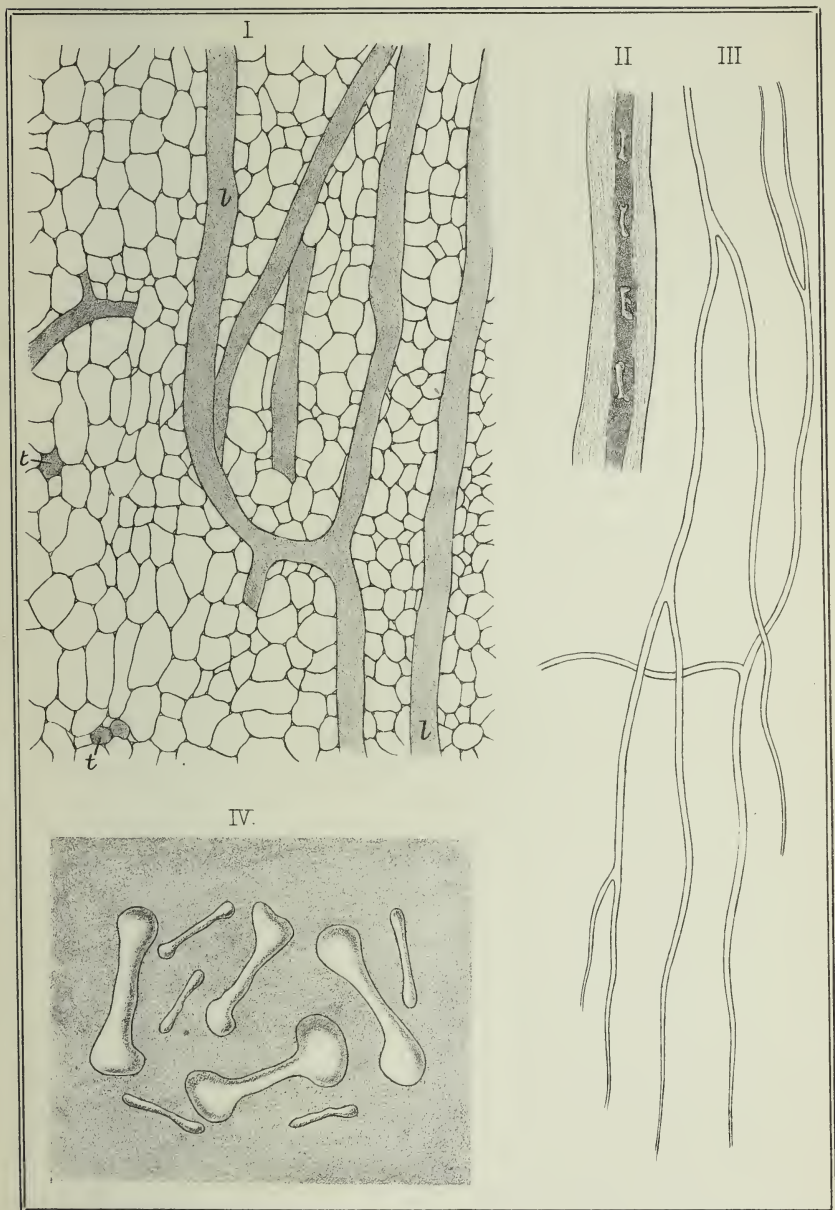
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NOTE.—It occasionally happens that when organs containing blood (either within their veins, or extravasated) are hardened in alcohol, that crystalline aggregates are formed within its plasma. These are the form of blood-crystals known as *hæmatoidin*. In some of the sections of the cat's spleen issued with this paper, many of these crystals obtain within the venous spaces, sinuses, and vessels, and add very considerably to the value of the preparation.

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del. and nat.

West, Newman & Co. lith.

EUPHORBIA SPLENDENS.

I x 65, II and III After Sachs, IV x 500.

EUPHORBIA SPLENDENS.

L. S. of Stem, Stained Logwood.

Etymology.—EŪ-PHÔR'BI-A, *n.* [Lat. *Euphorbium*, Gr. εὐφώρβιον, so-called by LINNÆUS after EUPHORBUS, a celebrated Greek physician in the court of JUBA, king of Mauritania. Literally well-fed, from εὖ, well, and φαρβειν, to feed, φαρβή, food.]

SPLĒN'DENS, *a.* [Lat. *splendens*, *p. pr.* of *splendere*, to shine; It. *splendente*, Sp. *esplendente*, shining, glossy, lustrous.]

EXPLANATION OF PLATE.

FIG. I.—L. S. Stem of *Euphorbia splendens*, a portion of the cortical parenchyma showing branched laticiferous cells $\times 65$. *l.* Longitudinal section of laticiferous cell, *t.* Transverse section of laticiferous cell.

FIG. II.—Isolated laticiferous cells from the end of a branch of *Euphorbia splendens*, exposed by maceration (slightly magnified). [After SACHS, *Text-Book of Botany*, Oxford, 1882, p. 86, Fig. 71, A.]

FIG. III.—A portion of one of the laticiferous cells of *Euphorbia splendens*, to show latex containing peculiarly shaped starch grains (strongly magnified). [After SACHS, *Loc. cit.*, Fig. 71, B.]

FIG. IV.—Dumb-bell, and bone-shaped starch granules from the fresh latex of *Euphorbia Splendens*, $\times 500$.

DESCRIPTION.

Euphorbia splendens affords a well-marked example of a plant in which laticiferous cells are remarkably well developed.

In his considerations on the 'forms and systems of tissues', SACHS¹ has embraced under the term *Idioblast*² those cells which become developed in a manner strikingly different from the cells of an otherwise homogeneous tissue. He divides idioblasts into morphological groups, and to each of these he has applied special names.

The laticiferous cells of *Euphorbia splendens* are developed in the fundamental cortex of the apical growing point of the young stem, and as they continue to develop, and to keep pace with the linear growth of the plant, they ultimately become converted into a series of much elongated tubes which branch, but do not anastomose to form cell-fusions. Strictly therefore, they are cells, and must not be confounded with the true laticiferous vessels which form a reticular system throughout the tissues of such plants as *Scorzonera hispanica*, *Papaver*, *Sanguinaria*, etc. Their form led DAVID³ to compare them with the peculiar hair-like cells which obtain in the petiole of *Monstereæ*, and together with these they have been classed under the title of idioblasts by the specific name of *Trichoblast*.⁴

¹A *Text-Book of Botany*, Oxford, 1882, p. 84.

²Gr. ἴδιος, peculiar, proper, and βλαστός, sprout, germ.

³U. er die Milchzellen der Euphorbiaceen, Moreen, Apocynen, und Asclepiadeen, Diss., Breslau, 1872.

⁴Gr. ὀρίξ, τριχός, a hair, and βλαστός, sprout, germ. So called because they resemble epidermal trichomes (SACHS).

A power of about 65 diameters is sufficient for the general examination of these cells. It may be observed that they possess considerably thicker walls than the cells which compose the surrounding cortical parenchyma, and that they are of tolerably constant calibre throughout that region, although they are associated in greater numbers and exhibit a tendency to take longitudinal parallel courses in the immediate vicinity of the fibro-vascular bundles. In some sections branches from these individual cells may be noticed to penetrate through the fibro-vascular region, and to enter the medullary portion of the stem. These internal offshoots are distinguished from those of the cortex by being thinner-walled and of less diameter.

All the cells are filled with a milky latex, which occupies the interspaces of the contained protoplasmic sac of the cell. According to the recent researches of E. SCHMIDT¹, all the plants which exhibit laticiferous tubes of a compound character, show that their nucleated protoplasmic contents coalesce to form a large *symplast* which retains its optical and other inherent properties to the last.

Within the latex numerous starch granules of peculiar form are developed. Some of these are rod-like and slender, others simulate the shapes of long bones. Whilst a third variety are more or less distinctly of dumb-bell forms.

METHODS OF PREPARATION.

In order to demonstrate the true nature of the laticiferous cells, and to show that they are individual closed and branched tubes, it is necessary to macerate the tissues. For this purpose the end of a young stem should be chosen, and steeped in water, where it should remain in a warm place, until most of the soft parts have decayed and become pulpy; small pieces may then be teased out with needles under a dissecting microscope, and the dissociation will render the closed ends of the cells clearly visible.

In sections taken from the stem which has been hardened quickly in strong alcohol before the latex is allowed to escape through the cut ends, the starch grains may be seen in position within the tubes (see Fig. III.)

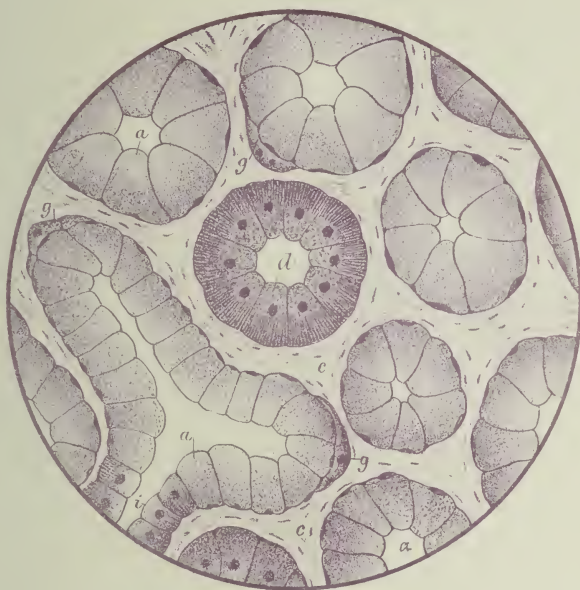
The methods of cutting and staining have been fully described at pp. 14, 16, 85, etc.

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H. del. et sc.

Wool, Newman & Co. lith.

V.S. SUBMAXILLARY GLAND
of Dog.
X 500.

THE SALIVARY GLANDS.

V. S. SUBMAXILLARY GLAND OF DOG.

× 500 diameters.

a. Gland Cells of Alveoli, *i.* Cells of Intermediary Duct, shown continuous with Epithelial Cells of Alveolus, *d.* Small Duct, with Epithelium showing well marked Longitudinal Basal Striation, *c.* Inter-alveolar Connective Tissue, *g.* Crescents of Gianuzzi.

Etymology.—SĀL'I-VA-RY, *a.* [Fr. *salival*, *salivaire*, Pr. and Sp. *salival*, It. *salivale*, Lat. *salivarius*] Pertaining to saliva; secreting or conveying saliva; as, *salivary* glands; *salivary* ducts.

DESCRIPTION.

In the general arrangement of parts the salivary glands approach most nearly to the pancreas, the minute structure of which has already been fully described¹. They are essentially of the compound tubular type. The glandular portion of the structure consists of branched tubes of various lengths, they are greatly convoluted, and present wavy outlines (GRO²). In direct continuity with these tubular alveoli, canalicular systems arise, and, by their union, finally culminate in the excretory duct of the organ.

The whole of the structures just enumerated, are invested in a framework of fibrous connective tissue.

THE FRAMEWORK consists of a fibrous connective tissue, almost entirely of the gelatigenous variety. The fibres are arranged in lamellæ between which their corresponding corpuscles obtain. The entire organ is surrounded by a moderately thin capsule of this tissue from which inward trabecular processes of various sizes pass, and divide the gland substance into lobes and lobules. The interlobular trabeculæ support the larger vessels and nerves, and also envelop the portion of the canalicular system known as the *lobar ducts*; these ducts, as well as the large excretory duct into which they lead, possess a variable amount of non-striated muscular fibres included in their walls (KLEIN³).

¹See this Journal, pp. 205—208, 217—220.

²*Hofmann's Jahresbericht*, 1876, Bd. v, Th. i, p. 312.

³*Atlas of Histology*, London, 1880, p. 188.

The lobes are subdivided into lobules by a secondary trabecular system, in which the fibrous elements exhibit a tendency to diminish in definiteness, and become somewhat interlaced. The lobular trabeculæ lodge the ramifications of the vascular system and nerves, they also invest the finer ducts of the canalicular system, which thus come to be *intralobular*.

Each lobule is composed of many tubular branched alveoli, and the lobular connective tissue performs the office of holding these together; the trabeculæ are further sub-divided, and as they thus become interalveolar, their lamellar fibrous character seems to be replaced by a gradual transition into a simple homogeneous tissue, in which connective tissue corpuscles lie imbedded. There can be but little doubt that the layer of the connective tissue, which lies directly in contact with the alveolar gland substance, becomes fused into a membranous form; which, however, is not separable from the interalveolar matrix of the tissue. To this limitary expansion of the connective tissue the term *membrana propria* may be applied. BOLL¹ and LAVDOWSKY² have noted that in all parts of the connective tissue, other cells may often be detected; they occur either singly or in small groups, and are the form of connective tissue corpuscles, known as *wandering cells*.

THE GLAND SUBSTANCE, admits of a two fold division into a *Canalicular system*, and an *Alveolar system*.

The Canalicular System.—The ultimate radicles of this system,—the *intermediary ducts*, (v. EBNER)³, arise as direct continuations of the alveolar tubuli, and open into the minute intralobular ducts. They vary in their conformation and structure in different animals; in the submaxillary gland of the dog they are very short, and are lined with a single layer of somewhat cubical transparent cells, with sub-centrally placed spherical nuclei, which merge gradually into polyhedral forms to become identical with the alveolar cells on the one hand (see illustration *i.*), and on the other, pass into columniform cells of the intralobular ducts. In the submaxillary gland of man, the epithelium is reduced to a layer of endotheloid cells, and the duct is often branched before it enters the alveoli (GROT⁴.) In every case, the walls of these ducts seem to be composed of a basement membrane strengthened externally by the homogeneous interalveolar matrix, with its included corpuscles. *The basement membrane in this, and every other section of the canalicular system, seems to be the final outspreading of the connective tissue cells which have developed a homogeneous matrix only on their outer sides; this matrix as it becomes more and more strongly formed, differentiates into fibrillæ, and thus arise the fibrous lamellæ of the trabecular and capsular connective tissue.*

According to NUSSBAUM⁵, the action of osmic acid upon the submaxillary gland of the rabbit, shows the cells of the intermediary portion of

¹*Archiv für mikroskopische Anatomie*, B. l. iv, p. 146.

²*Zur fein. Anat. der Speicheldrüsen*, Max Schultze's *Arch.*, Bd. xiii, Heft 2.

³*Archiv für mikroskopische Anatomie*, Bonn, 1872.

⁴*Loc. cit.*

⁵*Archiv für mikroskopische Anatomie*, 1877.

the duct immediately adjoining the alveolar cells, as distinct from those of any other part, and he concludes from this, that they are specially concerned in the secretion of the salivary ferment. Recently, however, LANGLEY¹ has shown that these statements are incorrect.

The intermediary ducts are thus intralobular in location; they pass into other canals, which, from their position, have been termed *intralobular*. These *salivary tubes* of PFLÜGER², are surrounded by a delicate homogeneous connective tissue which, like that of the intermediary ducts is limited by a *membrana propria*. The epithelial cells which line these ducts vary in size, and thus produce an irregularity in the outlines of the ducts, which thus come to be wavy; in shape, the epithelial cells are columnar, and they possess somewhat centrally placed spherical nuclei. The protoplasm of the cells exhibits a reticular network, which is developed in a longitudinal direction, especially towards their basal portions; they thus seem to be striated.

By continued ramification, the intralobular ducts reach the trabeculæ which separate the lobules, and become continuous with the next section of the canalicular system, viz., the *lobar ducts*. These are confined to the trabecular system, and by repeated unions form larger and larger canals which ultimately coalesce to produce the principal duct. All the lobar ducts are identical in essential structural details. A transverse section of one of them shows that it possesses a relatively larger lumen than that of an intralobular duct. The epithelial lining consists of a single layer of very regular columnar cells, with spherical nuclei situated towards their periphery. The protoplasm is very distinctly striated in a longitudinal direction, and the nucleus exhibits an intranuclear reticulum (KLEIN)³. The epithelium rests upon the limitary expansion of the connective tissue, which now surrounds the duct with a layer of fibrous lamellæ, and exhibits unstriated muscle cells.

The *Alveolar System* constitutes the true gland substance; its relations to the connective tissue and the canalicular system have already been described. What is noteworthy here, however, is that the connective tissue between the alveoli terminates in the coalescence of a layer of original connective tissue corpuscles, whose processes branch, and are either filamentous or broad and membranous; the branches of contiguous cells coalesce, and a fenestrated membrane is thus produced, which closely invests the alveoli (HEIDENHAIN³ and others). Some of the processes merge into the superjacent connective tissue, and become involved in its fibrillar matrix, whilst others pass inwards to unite with the intercellular cement substance of the alveoli (BOLL).⁴

The cement substance which binds the cells of the alveoli together is clear and homogeneous, and when stained by means of a soluble coloured injection into the alveoli, appears like so many spaces; they were

¹*Phil. Trans. Roy. Soc.*, London, 1881.

²*Op. cit.*, p. 188.

³*Studien des physiol. Instituts zu Breslau*, 1868, Bd. iv.

⁴*Loco citato*.

described as such¹ by SAVIOTTI, LANGERHANS, EWALD, BOLL, CROT, and others, with regard to the pancreas and these glands; v. EBNER² stated that they were merely clefts without walls; HERING³ denies their existence as canals in the salivary glands, and LATSCHENBERGER⁴ with regard to the pancreas, whilst KLEIN⁵, who is probably right, regards them as filled with a cement substance.

The structural and physiological details of the alveolar cells, led LAVDOWSKY⁶ to classify salivary glands into three groups:—

(a) *True Salivary Glands*.—Examples.—The parotid gland of mammals, parts of the submaxillary glands of man and the guinea pig, the orbital and submaxillary glands of the rabbit. The lumen of the alveolus is small; its epithelial cells are somewhat cubical with much rounded angles, and occur in a single layer; their nuclei are peripheral in position and sub-spherical in shape; the protoplasm is granular (due to a dense network) and the nucleus exhibits an intranuclear reticulum (KLEIN⁷).

On stimulation of the sympathetic nerve in the rabbit and dog, the cells of the parotid gland were observed to become very opaque and greatly reduced in size. (HEIDENHAIN, KLEIN⁸).

(β.) *True Mucous Glands*.—Examples.—Submaxillary and orbital glands of the dog and cat, sublingual gland of man. The alveolar epithelium is formed of two distinct kinds of cells (see illustration *a* and *g*), which surround a relatively larger lumen than in the true salivary glands. The alveoli themselves are also larger than those of the last named organs.

(i.) The *mucous cells* (*a*), (HEIDENHAIN), line the alveolar lumen. When the gland is in a state of activity these cells are seen to be distended, and present shapes which are identical with the goblet cells of mucous membranes, *i.e.* they are of conoid forms terminating in pointed extremities at their proximal fixed ends which are imbricated together and coherent to the processes of the endothelium of the membrana propria. Their protoplasts show an intracellular network the interspaces of which are filled with a clear substance; in the active condition this *mucigen* (so termed by HEIDENHAIN⁹) becomes converted into *mucin*, and through excessive imbibition imparts a globoid aspect to the cells. In the passive state the cell subsides into the condition which has been figured (see the illustration *a*) and its basal portion exhibits a tendency towards a longitudinal striation. Prolonged stimulation of the gland reduces the cells into small densely reticulated granular forms, and resemble the second kind of cells which yet re-

¹*Ut supra*, p. 207.

²*Loco citato*

³*Ueber die Ursachen der höher Absonderungsdruck in der Glandula submaxillaris, Sitz. d. K. Akad., Wien, Bd. lxvi.*

⁴*Sitzungsber d. K. Akad., Wien, 1872, Bd. lxxv.*

⁵*Loco citato*, p. 190.

⁶*Loco citato*.

⁷*Loco citato*.

⁸*Loco citato*.

⁹*Pflüger's Archiv*, Bd. xvii.

main to be described. The nuclei of the cells in their normal condition, are closely adherent to the peripheral walls of the cell next to the basement membrane, and appear to be somewhat flattened; a full view of these nuclei shows them to be circular in contour.

(ii.) The *parietal cells*, or *crescents* of GIANUZZI¹ are lunular aggregates of small cells, which obtain at irregular intervals between the mucous cells and the basement membrane of the alveoli. Their protoplasts consist of a very dense reticulum with very little interstitial material (KLEIN), and hence appear to be granular. The cells are polyhedral in shape, and each one possesses a spherical nucleus (ASP)².

The stimulation of mucous glands (either by electricity or through chemical reagents), is attended at first by an increase in size of the mucous cells, and the secretion of a viscous fluid; prolonged irritation, however, exhausts the structure, and its mucous cells no longer retain their original aspect; they become small and granular, and look like the parietal cells of the crescents of GIANNUZZI. HEIDENHAIN³ and LAVDOWSKY³ have asserted that they are destroyed, and that their places are taken by a process of new cell-formation from the parietal areas; but EWALD⁴ regards these smaller granular cells as the shrunken remains of the mucous cells, consequent upon exhaustion, and KLEIN⁵ is of opinion that such is in reality the case; for, arguing by analogy, he finds that excessive stimulation results in the structural changes which have already been noted, and is accompanied by a watery secretion; *i.e.*, the cells have evidently discharged all their mucin, and have collapsed, and become both morphologically and physiologically like those of true salivary glands. He also states, that in the submaxillary gland of young animals all gradations are met with from "small alveoli with small lumen lined only with small 'granular' cells, and alveoli somewhat larger and lined either partly with mucous cells, partly with granular cells, or altogether with mucous cells to which are applied from place to place groups of 'granular' cells."

γ. *Muco-Salivary Glands*.—Examples.—The submaxillary glands of man and of the guinea pig. In these glands some of the lobules present all the characters of true salivary glands, and are in direct communication with smaller alveoli which are distinctly mucous glands, and *vice-versâ*.

Besides these three forms, BERMANN⁶ has observed that in connection with a large branch of WHARTON'S duct in many mammals, he has discovered a compound tubular mucous gland of unique structure.

THE VASCULAR SYSTEM.—The distribution of the blood-vessels, and the lymphatic circulation of the salivary glands, corresponds in all essential particulars with that which obtains in the pancreas⁷.

¹*Ber. d. K. Sächs. Ges. d. Wiss.*, Sitzung vom Nov. 27, 1865.

²*Centralblatt für die medicinisch Wiss.*, 1873, p. 565.

³*Loco citato*.

⁴*Beiträge zur Hist. und Physiol. der Speicheldrüse des Hundes*, Inaug. Dissert., Berlin, 1870.

⁵*Atlas of Histology*, London, 1880, p. 191.

⁶*Centralblatt für d. med. Wiss.*, 1877—1878.

⁷*Ut. supra*, p. 217.

THE NERVOUS SYSTEM.—The ultimate distribution of nerves in the salivary glands, is still a question *sub judice*. A plexus of medullated nerve fibres occur in the interlobular connective tissue, and exhibit ganglia here and there; occasionally some of them terminate in Pacinian bodies of a simple kind (KRAUSE)¹. At other times chains of unipolar ganglionic enlargements occur within the nerves. The researches of PFLÜGER² have shown that the medullated fibre which proceeds from the plexus, loses its medullary sheath on reaching the ducts and alveoli; the axial cylinder then pierces the membrana propria of the alveolus, and enters the duct directly; in both cases its fibrils penetrate the epithelial cells, and may even be traced to their nuclei. Other observers have denied PFLÜGER's statements entirely, but they receive support from the investigations of KUPFFER³, who traced the nerve fibrils to their terminations within the epithelial cells of the salivary glands of the cockroach.

METHODS OF PREPARATION.

The directions given at pp. 208, 218, 219, apply here also.

PFLÜGER'S METHOD OF DISSOCIATION.⁴—Permit the gland, preferably the pancreas of a rabbit, to lie in iodised serum of a light sherry colour for four days, then for two days in about 5 cc. of dilute chromic acid solution (1-50th per cent.) By this means the epithelial cells of the alveoli may be partially digested away, and detached from a wide hyaline sac which they by no means fill; this sac is the membrana propria of the alveolus.

To prepare iodised serum, "add 1 cc. tincture of iodine, and one or two drops of carbolic acid to 100 cc. *fresh* amniotic fluid, and filter⁵." Blood serum may be used where amniotic fluid cannot readily be procured.

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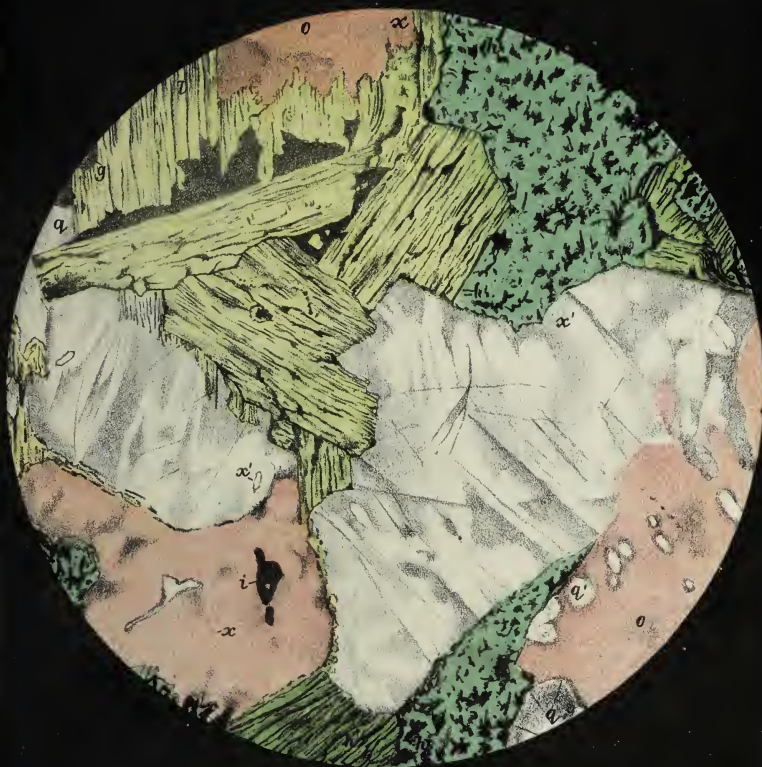
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del. ad nat.

Wool, Newman & Co. lith.

RED SYENITE
Ord Hill, Sutherland
X 25

RED SYENITE.

ORD HILL, SUTHERLAND.

× 25 diameters.

EXPLANATION OF PLATE.

l. Haughtonite, *o.* Orthoclase, *h.* Hornblende, foliæ horizontal, *h'*. Hornblende foliæ vertical, *q.* Quartz, full of air and fluid cavities developed in linear series, *q'*. Quartz within Orthoclase, *i.* Specular iron, *g.* Garnet, *x.* Crystals in Orthoclase, *x'*. Crystals in Quartz. These two last named are sometimes endomorphs of Quartz; at other, probably Topaz, and occasionally Beryl. The black endomorphs within the Hornblende are probably Thuringite or Rubislite.

DESCRIPTION

by

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Syenite,—so-called from the ancient quarries of Syene, in Egypt—is in its most typical form a granite, in which hornblende takes the place of mica. It, however, on the one hand, frequently loses its quartz, when it passes into *syenitic greenstone*, and is by many regarded as so passing into volcanic rocks; while on the other, it assumes mica, and becomes a *syenitic granite*. In the case of the first of these changes, it assumes *isérine*, and rarely *sphene* and *Biotite*, as characteristic accessory minerals; while, in the latter case, it assumes *sphene* commonly; and *Allanite* sparingly.

While both of the above varieties are common in Scotland—more common, in fact, than the rock strictly termed syenite—the latter variety is very much the more common, constituting tracts of many square miles in extent. Of the rock so occurring, it has also to be noticed, that the felspar which is generally in largest amount is *oligoclase*; while muscovite entirely gives place to one of the black micas—either Haughtonite, or Biotite. It is thus more fairly entitled to the term *micadiorite* than is the rock to which DELESSE applied that name. When the rock most closely resembles granite, quartz is always present; but as the hornblende and black mica increase in relative quantity, this quartz diminishes, and may be entirely, or almost entirely absent. To both the quartzose and non-quartzose modifications the term *grey granite* is applied, but correctly to only the first. It may prove to be the case that

the latter of these modifications is a plutonic, and that the former is a metamorphic rock.

A study of much of the granite of Scotland, especially of the grey granite, tends to the conclusion that it results from the metamorphism of the gneiss in which it is everywhere embosomed, and with which it is so intricately wrapped up.

The metamorphism appears to have taken place under three different sets of circumstances.

In the first :—By what may be called a gradual incrementation of the granitic over the normal gneissic structure.

In the second :—By an abrupt, and, as read by the eye alone, an inexplicably sudden transition of the latter into the former.

In the third :—By a general fading or softening away of the transmutable into the transmuted.

Throughout the whole of the gneiss of central Scotland, and more especially in those districts where the rocks exhibit the clearest marks of alteration, it is pervaded by granitic bands, which, there is reason to believe, have not unfrequently been considered to be intrusive or injected veins.

They are not so, but are merely the segregation apart of certain of the mineral constituents of the rock—like consorting with like—as evidenced by the following four facts.

These bands or layers of felspathic and quartz matter invariably follow implicitly every flexure of the rock (developed and disclosed by the adjacent micaceous layers), never cutting across these, nor branching to the smallest extent. They do not maintain anything of a uniform width, but repeatedly diminish and expand, in accordance with the abruptness or looseness of the folds into which the rock is thrown. Though highly felspathic, and often markedly crystalline, they exhibit unmistakably in some portion of their bulk, a laminated arrangement of particles; this becomes more and more distinctly pronounced as it passes into the ordinary structure of the rock. The blow of a hammer recognises no point at which the two structures are of facile separation; the transition of the one into the other being so gradual that no two persons would agree as to the point where each terminates,—and a hand's-breadth would not cover the debatable space. The ingredient of mica, moreover, is markedly *deficient* in these so-called granitic bands.

In what may be considered as an advanced state of this process, there is a marked increase in the number, and occasionally in the volume of these granitic bands; while there is now also a change in the nature of the bands themselves. They no longer exhibit a laminated structure, but are, throughout their whole extent, true granite of a more or less uniform grain. Here, although the hammer can still discover no line of separation, a finger's breadth will cover the space through which the structures pass one into the other.

The most advanced stage of the change is effected through the progressive augmentation in width of the granitic bands; those of gneissose structure simultaneously dwindling to evanescence.

There can be no question that the true features of these bands were recognised by JAMESON, who termed them "contemporaneous veins." He writes: "These veins do not present the slaty structure, which is one of the discriminating characters of gneiss when it occurs in strata; hence contemporaneous veins, filled with common granular, or what may be called granitic gneiss, have been confounded with true granite."

The view of the writer being that they are far from contemporaneous, but are the outcome of changes such as those which have had much light thrown upon them by the researches of DAUBREE, he, some years ago, proposed for them the term of *bands of metamorphic segregation*.¹

DAUBREE's experiments have shown that in the presence of water, a temperature of 400 cent. sufficed for the alteration of silicates,—crystallization of silica, and of felspar,—or, for the actual formation of the latter, and of mica, through the action of alkaline silicates on argillaceous rocks.

In the second mode of change, the gneiss passes into granite, with an abruptness which is quite startling.

The parent rock is frequently bold in feature, being highly contorted, and broadly banded, with its bands shewing a marked contrast in their colouration.

Between the gneissic and granitic portions of the rock, there is not a trace of interstitial skin, or intermediate mineral body. Most assuredly there has been no intrusion of the granite here; the one rock ceases to be, and the other commences along *no line* which can be seen or felt; there is no portion of space in which the one can be said to be in contact with the other. The continuity is everywhere unbroken, the material continuous; the eye alone appreciating a marked change of colour and of structure, for the openings between the foliæ of the gneiss suddenly cease to exist, but this they do not along a rectilinear but a wavering course. A hammer's blow rends the rock in any direction, the line of fracture crossing the zone of changed structure at all angles, and the straight course of the fracture being uninfluenced in the so doing.

The only modification of this structure is, that occasionally the dark mica of the granite has its plates disposed in arrangement somewhat parallel to the course of the transition, within the space of an inch or two from the unchanged rock.

In the third mode of change, a fine grained, plicated, and darkly-striped gneiss may be traced, with gradually fading layers, into a uniformly granular dark-grey granite.

In many of the Aberdeenshire quarries, moreover, semiangular fragments, large and small, of the darker and more micaceous layers of the gneiss, are found imbedded. These are rounded frequently in their outlines into kidney-form ("neres"), and darken the granite in their immediate vicinity by a quantity of the black-mica (Haughtonite) which these "neres" contain. It would appear that the plates of the black mica

¹ *Transactions of the Royal Society of Edinburgh*, Vol. xxix, where the subject is considered in detail.

have been loosened from the surfaces of the neres, and have become impacted in the adjacent substance of the granite, but have remained unresolved into smaller crystals; the metamorphism being arrested, or being incomplete at these points. It is from the dark mica which is the chief constituent of these neres, being almost invariably arranged in a laminated manner, parallel to their longer diagonal, whatever be the position of that diagonal—whether horizontal or vertical,—that we are led to conclude that these are not *concretions* in the rock, but unresolved fragments of gneiss, the metamorphosis of which resulted in the granitic paste which now holds these fragments imbedded.

Concretions show more or less perfectly a structure which is both radiating and concentrically zoned. *Segregations*, again, especially when micaceous, have a laminated arrangement of parts, which infolds either a central lamination nucleus, or a common centre of confused arrangement.

That the more *micaceous* portions of the gneiss should longest resist the alterative processes, is also quite in accordance with chemical requirements; this particular aluminous silicate being, *par excellence*, a chemical residue.

It is the *first* of the above modes of transmutation which concerns us at present; the locality whence I obtained the specimens of syenite, slices of which accompany the present number, being one where a transmutation very much of the same nature may be observed.

This locality is about two or two-and-a-half miles south-west of Lairg, in Sutherland, and stretches from the hill-slope called The Gruids, and the low ground to the south of this, to the rising ground termed the Ord Hill, a small rising ground hardly a mile distant from the hotel.

A great mass of a nearly white syenite lies to the east of Lairg, but does not approach within a quarter-of-a-mile or so of the village. This syenite is, for the most part, composed of a white felspar, in twin crystals, this is occasionally striated. From an analysis of the striated white felspar, which occurs in veins in the syenite, I set down this felspar as *oligoclase*—but with some doubt. A black mica and dark-green lustrous hornblende speckle the white rock,—the mica being somewhat in excess. As the mica of the *veins* of the rock is *Haughtonite*, that of the mass may be the same. It, however, does not weather *green*, as does that of the veins, but *brown*, like ordinary Biotite. This mica frequently occurs in clotted or segregatory lumps. Minute simple forms of brown sphene are the only other ingredient which is visible to the eye.

This mass of syenite is one of the largest in the country, stretching to within a few miles of the eastern shore line. The appearances to be seen in a small quarry half-a-mile east of Lairg, would seem to show that the syenite is igneous. Large masses of the gneissic rock are impacted in it, and it sends vein-like processes into, and almost coalescing with, the veins of the gneiss. These processes seem slightly to alter the structure of the contact-portion of the gneiss; though they also, in some spots, appear to shade off into it. The gneiss which is in contact with this syenite to the north, is a laminated and moderately convoluted rock. As we pass westward, however, to where

the river Tirry is crossed by the road to Overskaig, it is markedly flaggy, and has a N.E. to N.N.E. dip, at a low angle. Crossing the River Shin to the west,—on the south side of Loch Shin,—and passing westward to the locality of the red syenite which is the subject of the present notice, the rock is found to have the same dip, but to be more granitic in character,—though the foliation, bedding, and folding are still typically gneissic.

The surface is a great deal trenched by denudation, and strewed with loose blocks, at and near the Gruids, and between Rhian and Pitarxie. Ridges, which simulate veins, protrude here and again, quite similar in material to the loose blocks; hence these may not have been moved far from their original site; and, indeed, the rock, even a mile to the west, is merely the ordinary gneiss of Sutherland. The ridges which protrude have endured, through their being more granitic, or more correctly *syenitic*, than the general mass; and those to the west contain much of a peculiar green mineral, to which an imperfect acquaintance of its exact nature would assign the name of an altered feldspar. Even here the wrinkled layers of the gneiss are occasionally separated by thin bands of a highly crystalline red syenite. These bands are much more frequent, and of much more important bulk on the south side of the Ord Hill. From this the specimens which furnished the slices were broken.

Much of my description of the granite belts of the hill of Scoltie, in Aberdeenshire,¹ applies to the syenitic belts of the Ord Hill. The bands or layers of syenitic structure and composition “invariably follow implicitly every flexure of the rock, never cutting across these.” “They do not maintain anything of a uniform width, but repeatedly diminish and expand.” “Though highly felspathic, and often markedly crystalline, they exhibit in some portion of their bulk a laminated arrangement of particles, which becomes more and more pronounced as it passes into the ordinary structure of the rock.” “The blow of a hammer recognises no point at which the two structures are of facile separation; the transition of the one into the other being so gradual that no two persons would agree as to the point where each terminates.” There is this to be said of the Ord Hill bands, that they terminate *longitudinally* with, very frequently, a marked abruptness—an approach to rectangular truncation, and hence, in such cases, have some slight appearance of injection. The other extremity of such bands, however, throw off, and pass insensibly into a gneissic structure. No connection with any igneous mass, and no disrupting or troubling of the bedding could, moreover, be anywhere seen. The layers of gneiss, which were in immediate contact with the syenitic layers, were granitic or granulitic in structure; and this is different from what obtains at Scoltie, and elsewhere in Aberdeenshire, as a rule. Very generally there is there a band, more highly laminated from dominance of black mica, in contact with the granitic portion.

Such examination as the nature of the ground permitted was made, to ascertain if these syenitic belts were in any way related to the great mass of white syenite of Lairg; or, if there was an increase in the quan-

¹Loc. cit.

tity of the red syenite, as the eastern mass was approached. It was found that the red syenite disappeared, or, at least, could not be found on the east side of the Ord; the bands which were seen consisted of a large-grained melange of masses of white felspar and amorphous quartz.

The characteristic feature of the red syenite of the Ord is its brilliant red felspar. This is in fairly-well developed crystals, sometimes the size of peas. The red of these crystals is contrasted by the green of the hornblendic material, and by the white of the quartz. I have used the word hornblendic material, because all that the aid of the lens enables the mineralogist to say thereof, is that it does not, from its somewhat flake like or even feathery appearance, seem to be any of the more cleavable varieties which generally occur in such rocks. The aspect under the lens certainly does not prepare one for the very remarkable aspect which it bears in slices under the microscope; which its actual substance shows no evidence of alteration, the manner in which it is sprinkled, between its plates with crystalline endomorphs, vouches for change. Of all known dark green products of such alteration, Thuringite or Rubislite seem to me the most probable minerals to which these branching crystals are to be assigned.

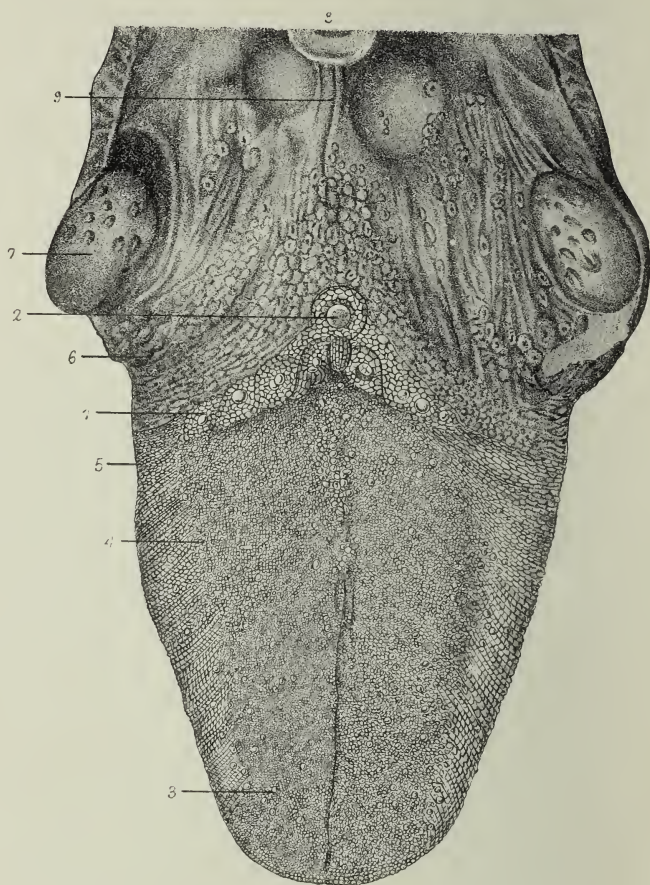
The striated felspar,—probably oligoclase,—is unaltered; while the orthoclase has suffered considerably. This is a point of interest.

The question whether the great igneous mass of white syenite (if it be igneous) in any way originated or urged on the metamorphism seen at the Ord, is a fair one for speculation.

MURCHISON makes the very similar mass of Syenite which forms Ben Loyal break through and tilt up upon its flanks the gneiss, to east and west. Nothing of this kind is seen at the junctions of the Lairg Syenite with the surrounding rocks: these are undisturbed, and lie not far removed from horizontal bedding. The small dip which they have being in the same direction as that which occurs away to the west.

Again, as has been noticed, the rock of the Ord is more altered, and its bedding somewhat more disturbed, *at a distance* from the white Syenite, than it is in proximity to it. While, again, the small amount of alteration visible in those portions of the gneiss which are in contact with the white Syenite, goes far to discredit the view that the latter can have influenced beds comparatively distant.

It is true that it is quite possible that though the two rocks are now distant, they may not have been always so. A line of outliers of Old Red Conglomerate, which trend to the westward of the line of the Ord, vouches for an enormous denudation; a denudation which may have scalped off not only the whole thickness of the conglomerate, but also an overlying sheet of an igneous rock. Unless, however, we deal in speculations which the facts do not warrant, we are not entitled to assign any part of the change effected on the rocks of the Ord to other than *internally operating forces*.

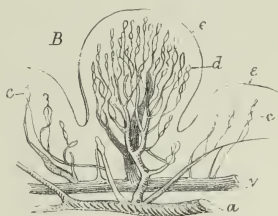
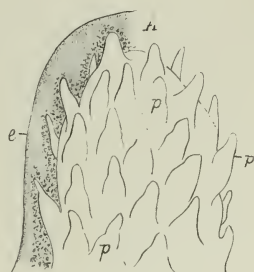
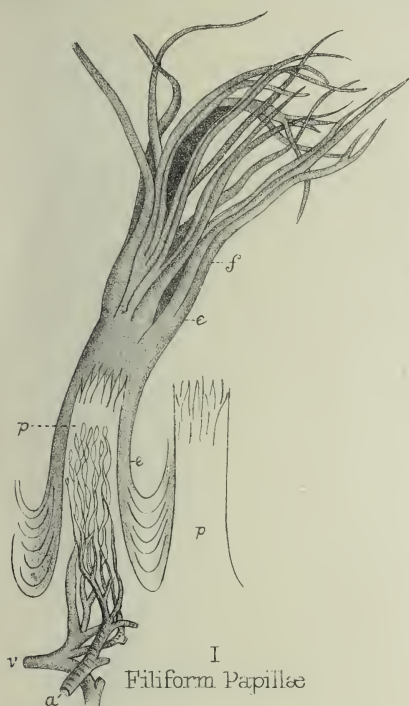


del. ad. rat.

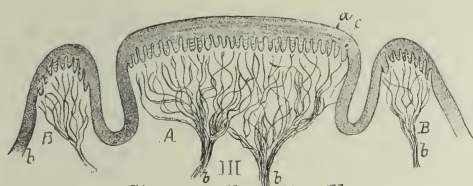
HUMAN TONGUE

Papillar surface with fauces and tonsils.

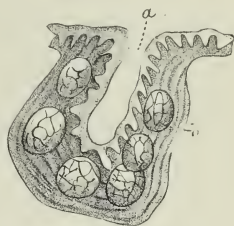
(SAPPEY.)



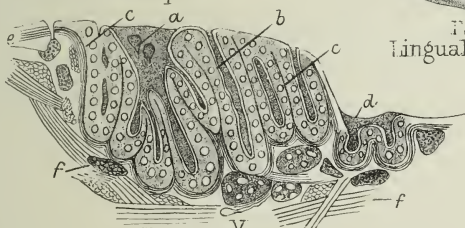
II
Fungiform Papillæ



III
Circumvallate Papilla



IV
Lingual Follicle



V S. of Tonsil

West, Newman & Co. lith.

THE TONGUE
Papillæ, Glands, & c.

THE ALIMENTARY CANAL.

Etymology.—^uAL'I-MĒNT'A-RY, *a.* [Lat. *alimentarius*, Fr. *alimentaire*, from Lat. *alimentum*, from *alere*, to feed, nourish ; pertaining to aliment or food].

CAN-ĀL', *n.* [Fr., Pr., Sp., and Pg., *canal*, It. *canale*, from Lat. *canalis*, originally adj. from *canna*, reed, pipe, a small vessel, Gr. *κάννα*, or *κάνννη*, reed, and anything made from it, A-S. *canne*, D. *kan*, O. H. Ger and Sw. *kanna*, N. H. Ger. *kanne*, Eng. *can*, a cup or vessel, in modern times made of metal].

Comparative Anatomy.—The term alimentary canal is only strictly applicable to the nutritive system of that section of the animal world known as the *Metazoa*, although it is foreshadowed in some of the higher unicellular organisms amongst the *Protozoa* in the form of an indistinct tract.

Amongst the lowliest organisms, the extempore formation of an alimentary system may be studied in some of the simpler *Amæbæ* ; the food particles come into contact with the undifferentiated mass of protoplasm of which their bodies consist, and which in virtue of its tactile properties, exercises a selective faculty in accepting suitable matters and discarding inappropriate substances. When a particle of food comes into contact with the outer wall of the organism, which exists in water, its superficies become raised up on each side of the food, and eventually coalesce around the mass ; thus enveloped the food passes into the less dense portion of the body, and is digested ; a sort of stomach is thus formed for the time being, and is termed a *food-vacuole*. The undigested portions are evacuated from the body by a similar but inverse process. Thus it appears that any parts of the body-wall are converted into extempore oral and anal regions, and the whole of the protoplast may be looked upon as an alimentary tract. Amongst the higher *Amæbeæ*, definite areas of the body are restricted to the reception and ejection of food particles.

The ingestion of food amongst the *Protozoa* has not been fully investigated with regard to the forms which develop internal and external hard parts (*e.g.*, *Foraminifera*, *Radiolaria*) ; and in the *Gregarinidæ*, where the animals are dependent upon their parasitic habit, it is supposed that the nutritive processes are provided for through imbibition.

By far the most interesting in this respect amongst the *Protozoa*, are the *Infusoria* ; not only do they develop many food vacuoles, but these are generally formed at the base of an oval depression, and excrementitious particles are ejected from a definite area. The oral region sometimes leads into a vestibular space, from which a short permanent channel, the oesophagus, extends within the body as far as its endosarc, where it terminates abruptly (*Vorticella*). The food, which is directed into the oral cavity, through the agency of its fringing cilia, becomes enveloped

within the endosarc, and forms the so-called food vacuoles; these, in their turn, circulate through a definite tract of the endosarc, and the refuse is expelled into the vestibulum through an extempore anus, which, however, is defined in position. The circulation of the food vacuoles within the almost fluid endosarc may be well seen in *Balantidium*, and in *Paramœcium*, where the movement is very regular and confined to a more limited tract (COHN). In *Nyctotherus*, this limitation becomes still more evident; the food passes from the end of the œsophageal depression straight down the body along an "intestinal tract," to the region of the temporary anus at the other extremity of the body.

Yet further modifications of the alimentary tract have been observed amongst the *Infusoria*. The oral cavity, which is usually ciliated, is sometimes provided with a corneous armature, as in *Dysteria* and *Didinium*, and may entirely give place to a folded membrane in this region, as in *Torquatella* (HUXLEY,¹ BALBIANI, LANKESTER).

The early life-history of the sponges, which has been carefully detailed in the case of *Sycon ciliatum* by METSCHNIKOFF², shows that the *Porifera* belong to the *Metozoa*. The impregnation of the ovum results in the development of a *morula*, or mulberry mass of cells; the internal delamination to form a *blastocœle* and its subsequent opening at one end to complete the *gastrula* of HÄCKEL³ brings the embryo sponge to the threshold of the permanent condition of the *Cœlenterata*,—it is merely a cylindrical body with a simple tubular alimentary canal. The subsequent phases of its life are attended by degenerative changes whereby its original alimentary tract becomes more or less parcelled out into limited areas or channels, which perform the function (through ciliary action) of drawing in water and food through inhalant apertures, which is finally expelled by the large exhalent pore. This, with minor modifications, constitutes the alimentary canal of the *Porifera*.

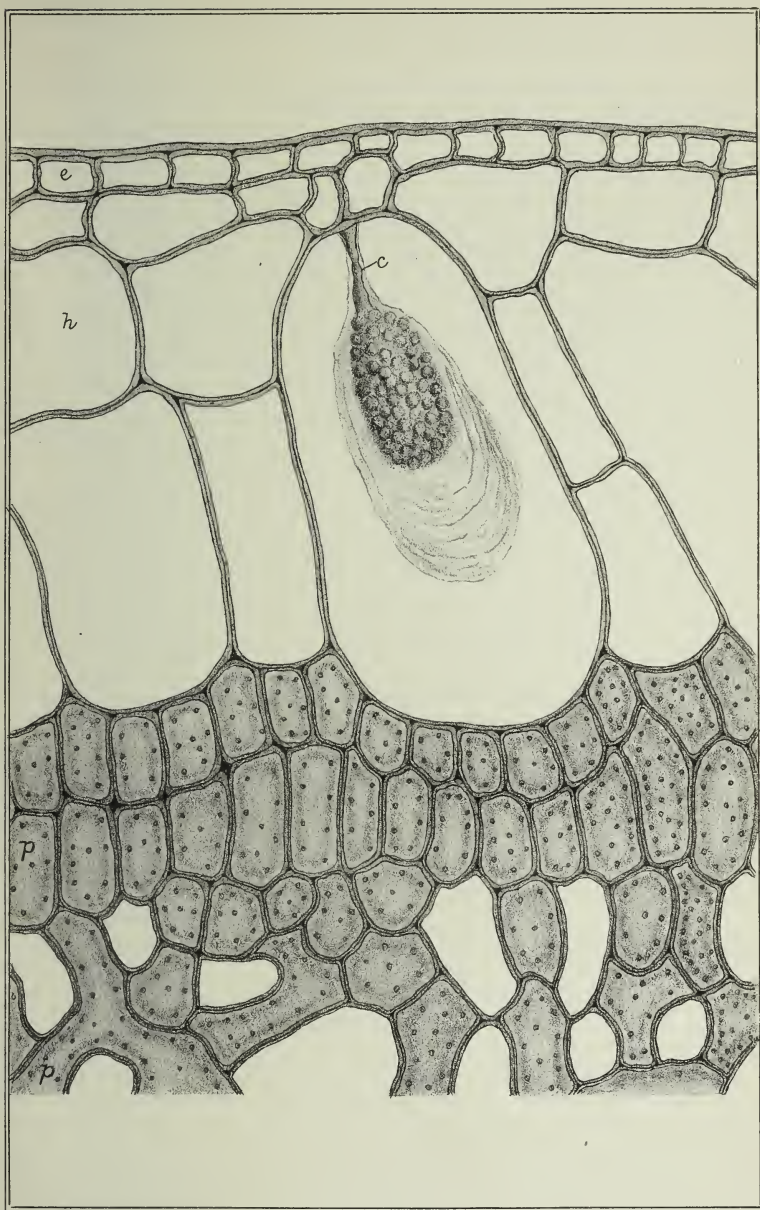
The *gastrula* then affords a type of a simple animal in which the alimentary tract remains a simple sac, and leads naturally to the permanent form of the cœlenterate *Hydra*; here the alimentary canal is lined by a single layer of endodermal cells,—the derivatives of its hypoblast. Throughout the remainder of the *Cœlenterata* this type remains constant, and is even unchanged in the aprocuous *Turbellaria*, as in *Macrostomum*. In the proctucous *Turbellaria* a slight advance is made in the development of an anus and the sac thus becomes a tube.

The *Rotifera* and *Polyzoa* both present a well developed alimentary canal, in which the tube becomes differentiated into an oral cavity, pharynx, œsophagus, stomach and intestines. Into this region of the body various glands open at different parts of its course, and these become more complex and varied in a progression towards the vertebrated types, where they reach their maximum of development.

¹On *Dysteria*, *Quarterly Journal of Micros. Science*, London, 1857.

²*Zur Entwicklungsgeschichte der Kalkschwämme*, *Zeits. für Wiss. Zoologie*, Bd. xxiv.

³*Die Gastrula und die Eifurchung der Thiere*.



del. ad nat.

West, Newman & Co. lith.

FICUS ELASTICA.

T.S. Upper Portion of Leaf with Cystolith.

X 333.3



FICUS ELASTICA.

T.S. Upper portion of Leaf, Stained Logwood.

× 333·3 diameters.

c. Epidermis, *h.* Hypodermis, *p.* Pallisade Parenchyma with Chlorophyll Bodies, *p'.* Inner Loose Parenchyma with Chlorophyll Bodies, *c.* Cystolith.

Etymology.—*FICUS*, *n.* [Lat. *ficus*, A-S. *fic*, Fr. *figue*, Pr. *figa*, *figua*, O. Sp. and Pg. *figo*, N. Sp. *higo*, It. *fico*, O.H. Ger. *figâ*, N.H. Ger *feige*, D. *vyy* or *vijg*, Eng. *fig*.]

E-LÄS'TIC-Ä, *a.* [Lat. *elasticus*, from Gr. *ἐλαύνειν* to drive, Eng. *elastic*, that property in virtue of which a body recovers its former shape or bulk after the distorting force has been removed.]

DESCRIPTION.

The General Arrangement of Parts.—In a transverse vertical section of the leaf, a portion of the upper surface of which is shown, in the accompanying illustration, the upper surface may be seen to be bounded by a single row of somewhat cubical cells,—its *epidermal layer*. Beneath this comes a layer of *hypodermal* cells disposed in about three layers; at irregular intervals, the cells of this layer become modified and are known as *lithocysts*. Underneath this comes a layer of pallisade parenchyma the cells of which exhibit chlorophyll bodies and, through their opacity, form a very definitely marked band midway between the upper and under boundaries of the leaf. The pallisade parenchyma passes into a loosely arranged system of cells, which also contain chlorophyll bodies, and these form nearly half the depth of the leaf structure; they are limited below by a boundary of cubical cells, the *lower epidermis*, which, in some instances, is stratified.

The Epidermal System.—The upper and lower epidermal layers resemble each other in being composed of somewhat cubical cells, the outer parieties of which coalesce to form a cuticular layer. Stomata occur but sparingly in the upper, but are of commoner occurrence in the lower stratum. The lower epidermis, moreover, is usually strengthened by a second layer of cells, developed inwardly to pass into the loose texture of the chlorophyll-bearing areolar parenchyma which surmounts it.

The Hypodermal System.—Beneath the upper layer of epidermal cells, a zone of about three layers exists; the uppermost of these layers consists of cells somewhat larger than those of the overlying epidermal cells; underneath this the cells become enormously enlarged, and their cell walls at the same time decrease in thickness. The junctures of the cell walls of this tissue at their angles are thickened, like that of collenchymatous tissue.

Every here and there, an *idioblast* is formed; *i.e.*, a cell exhibiting peculiarities. These cells become much larger than the surrounding elements, and a kind of delicate sac is developed from their walls, and

remains suspended from and attached to only the upper extremity of the cell. Within the sac a botryoidal cluster may be seen closely ensheathed in a protoplasmic lining, and is fastened to the upper cell-wall by means of a hyaline flexible pedicle. To the modified cell and its sac, the term *Lithocyst* has been applied; and the contained cluster has been called a *Cystolith*.

Regarding the cystolith, SACH'S¹ makes the following statements:—"The body of the cystolith is hard and brittle, the stalk flexible. In a dark field of view between the crossed Nicols, I have found the cystoliths of *Ficus elastica* not luminous even in small fragments; they do not polarise light; the calcium carbonate cannot therefore be deposited in a crystalline form. Nothing of a crystalline character can be detected in the body itself (see Hofmeister, *Lehre von der Pflanzenzelle*, p. 180). If the object is treated with acetic acid, bubbles of carbonic acid gas are developed in the neighbourhood of the cystolith, while the previously opaque substance of the concretion becomes gradually transparent from without inwards. Finally there remains behind an insignificant skeleton of an organic matrix, in which the calcium carbonate was evidently deposited in the finest state of division. No cavities are to be seen out of which crystals can have disappeared; the matrix is perfectly homogeneous. Neither is there any reason for assuming that the lime was deposited between the layers of the matrix; since the outer portion of the mass, which contains an especially large quantity of lime, is quite unstratified. There is, on the other hand, a central nucleus, in direct connection with the stalk, which is much denser than the external portion, and manifests an evident transverse stratification, as well as radiating fibres of a denser substance, which are obviously a faint indication of an intersecting striation. On addition of Schultz's solution the stratified and striated nucleus of the matrix assumes a beautiful dark blue colour, the outer portion only a light blue; the former consists of denser, the latter of more watery cellulose, between the molecules of which those of the lime have been deposited. The cystoliths originate (in *Ficus elastica* on Schacht's authority, in *Broussonetia* from my own observation) as wart-like outgrowths from the inner side of the cell-wall, which then swell up into a club-shaped form at their free end, and become impregnated with lime. After the lime has been dissolved and solution of iodine added, it is seen that the surface of the cystolith is coated with a thin protoplasmic membrane, in which the original sculpture of the whole can still be perfectly made out."

The Ground Parenchyma consists of a pallisade parenchyma of two to three cells deep, which passes into a looser texture of branched cells, with large intercellular spaces. All these cells contain chlorophyll bodies; the protoplasmic contents of the columnar cells of the pallisade parenchyma, are somewhat denser than those of the other elements. Within the ground parenchyma branched fibro-vascular bundles may be seen, cut in various ways.

METHODS OF PREPARATION.

See this Journal pp. 14, 16, 85, etc.



Fig. 10. ad nat.

100x, H&E, stained, 100x

V. S. TONGUE OF DOG.

Circumvallate Papilla

X 55

THE ALIMENTARY CANAL.¹

THE ORAL CAVITY.

Etymology.—O'RAL, *a.* [Fr. and Sp. *oral*, It. *orale*, from Lat. *os*, *oris*, the mouth, pertaining to the mouth].

DESCRIPTION.

In the human subject, the epidermal layers and *cutis vera* of the skin, the histological anatomy of which has already been described,² pass gradually into the mucous membrane and mucosa of the oral cavity through a transitional part,—the red part, seen even when the lips are closely apposed.

The epidermis becomes slightly modified to produce a more delicately formed *stratified squamous epithelium*; the external corneal layer of the epidermis, the cells of which have lost their protoplasmic contents, and are mere periplasts, here assumes a vital aspect in its flattened nucleated scaly cells; and these pass into a zone of prickle-cells, which are identical with those of the *rete mucosum* of the skin, and like them are endowed with the power of proliferation by a similar process, viz.:—the formation of linear series of vacuoles (RUTHERFORD³). The deepest layer consists of epithelial cells, which are somewhat columnar in shape, and possess centrally placed oval nuclei; their basal portions are usually branched, and the processes dip down into the subjacent mucosa. The superficial cells of the epithelium in man are usually much flattened, and possess flattened oval nuclei; in most mammals, however, they bear only traces of nuclei, and become fused into a yellowish horny expansion.

Between the epithelium and mucosa, a *basement membrane* exists. It consists of branched endothelial cells, which are doubtless formed by the coalescence of a layer of connective tissue corpuscles to form a membrane, an *endothelial membrane*⁴.

The *subepithelial mucosa*, varies in amount in different parts of the oral cavity. It is thickest on the buccal region proper, and the angle of the mouth and lips; it thins away on the soft palate, the palatine arches, and the bottom of the mouth. Its texture becomes firmer, and its depth

¹Continued from p. 258.

²*Ut supra*, pp. 25—38.

³*A Text-Book of Physiology*, Edinburgh, 1880, p. 67.

⁴The term *endothelium*, (Gr. *ἐνδον*, within, and *θηλή*, nipple, papilla), is here used in its literal sense. It was first employed by HIS to denote epithelium of mesoblastic origin, but, as only confusion resulted from such an arbitrary use of the term, it gradually came to be restricted to membranes which consist of a single layer of squamous cells, irrespective of their situation, or their embryonic origin. To such membranes the term *endothelial* (Gr. *ἐνδον*, and *τιθέναι* to lay, to put) might be applied with some degree of significance, and at the same time only slightly modify the existing nomenclature.

less, over the hard palate and gums; this is due to the tendinous nature of the fibrous tissue which becomes fused to the underlying periosteal membranes. In histological structure, it is composed of a delicate fibrous connective tissue of the gelatigenous variety, arranged in decussating trabeculæ, and is very rich in connective tissue corpuscles, the nuclei of which become deeply stained in tinged sections. Many interfascicular spaces exist amidst this tissue, and serve as channels for the percolation of lymph. Elastic fibrillæ also intertwine amongst the trabeculæ, and may be readily detected by their high refractive indices. Finally, the mucosa is raised into numerous vascular and nervous papillæ over which the basement membrane is reflected, and between which the prickle-cells of the epithelium form the so-called interpapillary processes.

In some mammals, more notably in the ox and sheep, the mucous membrane of the mouth, at its entrance, is beset with many large well-developed papillæ which project high above the general surface, and are covered by a layer of epithelium somewhat after the fashion of the *papillæ filiformes* and *fungiformes* of the tongue; they are absent in the adult human being, but KLEIN¹ has noted their occasional occurrence in the newly-born infant.

The mucosa passes gradually into a more loosely arranged zone in which the bundles of fibrous tissue tend to take on a lamellar disposition; they thus give rise to larger and more definite interfascicular channels, are invaded by clusters of fat cells, are penetrated by the larger trunks of blood-vessels and nerves, and lodge the glandular elements. Bundles of striated muscular fibres also connect this layer with the surrounding fascia and give to it a degree of contractility, whilst its relations to the surrounding organs such as the skin, periosteum, etc., is further effected through modifications of its fibrillar elements into the corresponding portions of those parts. To this illimitable region the term *submucosa* or *submucous tissue* has been applied.

In certain situations (e.g., the soft palate and tonsils), masses of lymphoid tissue are developed, and KLEIN² has observed that this adenoid tissue, with its lymph corpuscles, sometimes encroaches on the superjacent epithelium through active growth.

Of special interest are the glands which everywhere obtain in the tissues of the oral cavity. They are all of the nature of mucous glands, and as such, belong to the compound tubular type. In all essential details they resemble in miniature, the larger mucous glands which are concerned in the secretion of part of the saliva, and which have already been fully detailed³. The largest of these glands are to be found in the soft palate and lower lip. Each gland commences in a duct which opens on to the surface by a funnel-shaped orifice; the duct then passes through the mucosa generally in an oblique direction; on reaching the submucous tissue it subdivides, and each branch continues in a downward course to ultimately dilate into a wider portion termed the *infundibulum*, into which

¹*Atlas of Histology*, London, 1880, p. 194.

²*Op. cit.*, p. 195.

³*Ut supra*, p. 246, *et sequentes*.

the branched alveoli of the gland proper open. The superficial epithelium of the soft palate in the human fœtus is usually stratified, and its outermost cells are fringed with cilia; this disappears in the adult, but traces of cilia are sometimes met with at the commencement of the ducts of the mucous glands (KLEIN¹). In the anurous *Batrachia*, as in *Rana*, the ciliated epithelium persists throughout life, over the entire mucous membrane of the mouth, pharynx, and œsophagus. The stratified cells of the epithelium which surround the orifice of the glandular ducts dip down, in the case of man, into its funnel-shaped depression; in other mammals this is carried to a still further extent, and the attenuated stratified epithelium reaches the deeper portion of the tubule. In both cases, however, it ultimately passes into a layer of columnar cells, each containing a centrally-placed nucleus; the entire protoplasm of the cells exhibits a reticular network, longitudinally disposed in the perinuclear parts. In the region of the submucosa, the lining cells of the duct become somewhat polyhedral and granular, and pass suddenly into the larger mucous cells of the infundibulum. This transition is by no means regular, for KLEIN² has noted, and admirably figured, a part of this intermediary duct, in the case of the dog, where the polyhedral cells of one side of the duct pass suddenly into the mucous cells of the infundibulum long before that change is observable on the other side of the duct. The characters of the mucous cells have already been fully detailed³; in this place, however, it may be observed that the crescents of GIANUZZI, where they have been observed, are but poorly represented; and that in the early stages of growth the mucous cells are short and granular, possess sub-centrally situated spherical nuclei, and surround but a diminutive lumen, whilst in the fully-developed gland the alveolar cells are large, possess a marked reticular network, flattened basal nuclei, and surround a relatively large lumen. The lumen of the duct, too, is comparatively large.

All portions of the gland are invested in a basement membrane, which shows every here and there a flattened spindle-shaped nucleus, and becomes directly continuous with the sub-epithelial *membrana propria*.

THE BLOOD-VASCULAR SYSTEM.—The submucous tissue lodges the larger vascular twigs; from the arteries branches proceed through the mucosa in an oblique direction, to become resolved into a network of horizontally disposed capillaries in its upper strata, whence looped capillaries arise to supply the papillæ. The efferent vessels originate in the capillary network, and produce a network of their own; thereafter they join the larger veins in the submucosa.

The glands are provided with vessels of their own, which are distributed after the manner of those which supply the pancreas⁴ and salivary glands; and afferent and efferent vessels convey blood to and from the striated muscular elements, the adenoid tissue, and fat clusters in a manner characteristic of those structures.

¹*Op. cit.*, p. 195.

²*Op. cit.*, p. 196, Pl. xxxii, Fig. xvi.

³*Ut supra*, pp. 246—247.

⁴See this Journal, p. 217.

THE LYMPHATIC SYSTEM.—The researches of TEICHMANN have shown, that the submucous lymphatic vessels send valvate branches into the upper portion of the mucosa, where a superficial plexus of capillaries is formed; from this network, looped diverticula pass into the papillæ. The interfascicular spaces of the connective tissue form irregular lymph-rootlets which merge into definite canals, lined by a layer of connective tissue corpuscles, which thus form walls for these channels; when the corpuscles unite to form a distinct membrane a capillary is produced, and this joins the general lymphatic system. The epithelium, moreover, possesses a lymphatic system in the vacuoles of its so-called prickle cells.

THE NERVOUS SYSTEM.—The larger nerve trunks which lie in the submucosa ramify to terminate in a plexus of fine fibres in the mucosa; from this, fibrils are given off, and thus arises the fine subepithelial plexus from which still finer branches pass into the epithelial layer. Bodies which simulate the forms of end bulbs and tactile corpuscles, have also been detected in some of the larger papillæ of the lips of certain mammals (KRAUSE, KÖLLIKER, GERLACH).

METHODS OF PREPARATION.

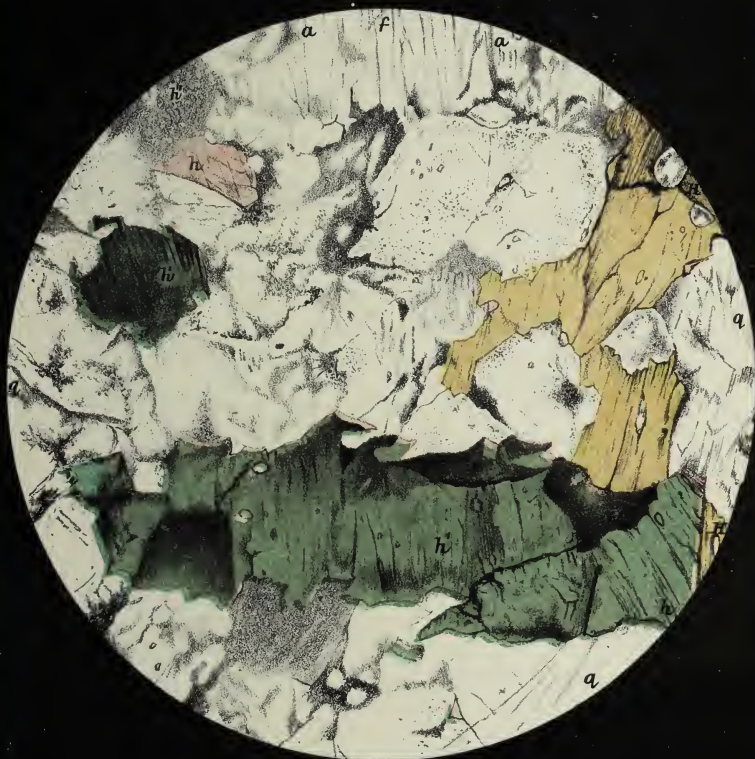
Small pieces of the lips, and portions of the tissues of the oral cavity may be hardened in either of the following solutions:—

(i.) *Chromic Acid and Spirit Mixture.*—This solution should act upon the tissues for about twenty-four hours, and then renewed. At the end of two weeks alcohol should be substituted, and in this they may remain until they are required.

The only drawback to this solution, or to any solution of chromic acid, is, that the striated muscular elements of organs are apt to become dissociated.

(ii.) *Ammonium Bichromate Solution.*—A solution made by dissolving 20 grammes in 1,000 cc. of distilled water, should be used. The tissues should remain in this for about twenty-four hours, and should thereafter be removed to a fresh solution, in which they may remain for about three weeks; they should then be transferred to alcohol until most of the yellow colour is discharged, and retained in alcohol until required.

The sections may be stained with logwood or picrocarmine, and mounted in Canada balsam or Farrants's solution.



del. ad nat.

West, Newman & Co lith.

WHITE SYENITE.

Lairg, Sutherland.

X 25

WHITE SYENITE.

LAIRG.

× 25 diameters.

EXPLANATION OF PLATE.

f. Part of a crystal of Orthoclase with Endomorphs of Albite (*a*),
q. Quartz full of Air and Fluid Cavities, Developed in Linear Series,
H. Haughtonite Enclosing Crystals of Apatite, *h.* Hornblende of a Brownish Tint cut at Right Angles to the Dominant Cleavage, Showing *m* Cleavages, *h'.* Hornblende Showing Flat Green Foliations of its Dominant Cleavage, Parallel to *m*, *h''* Hornblende of a Greyish Tint, which Polarise Feebly, and are Sprinkled with Dotted Markings which Probably Result from a Diagonal across the summits of the Rhombic Cleavages of *h.* In the Large Green Patch Marked *h'*, a Few Clear Crystals of Apatite are Shown.

DESCRIPTION

by

M. FORSTER HEDDLE, M.D., F.R.S.E., ETC., ETC., *Professor of Chemistry in the University of St. Andrew's, Past-President of the Mineralogical Society of Great Britain and Ireland.*

“He who, with pocket hammer, strikes the edge
Of luckless rock or prominent stone, disguised
In weather stains, or crusted o'er by nature
With her first growths—detaching by the stroke
A chip or splinter, to resolve his doubts;
And, with that ready answer satisfied,
The substance classes by some barbarous name,
And hurries on.”

But how seldom are the doubts *definitely* solved by a lens examination of the chip or splinter! The barbarous name even may, however, be got rid of, when the microscope and the balance tell us many things we could not attain to by the most diligent use of the hammer, even when there was no hurrying on.

It is very seldom unfortunately that the histological petrologist is in possession of absolute information as to the nature of the substances which he views in the field of his microscope. Of many he can speak from the confidence engendered by experience; though lately there has appeared to be reason for concluding that there has been, not unfrequently, too much

of confident assurance in his deductions. Of several substances he would be willing to admit that from deduction alone did he draw his conclusions; the precise grounds for which he would himself have some difficulty in furnishing. In most cases would the candid naturalist welcome assurance being made doubly sure by analyses of the materials of which he wrote.

Though I am not able to furnish absolutely such firm ground for assurance in the present case, I do something very closely approaching thereto, in supplying analyses of the constituents of exfiltration veins, which occur in this Syenite.

That such veins have resulted from the rock throwing out from its own mass the material of its own substance in a state of solution, to fill rents which have traversed it, there can be no reasonable doubt.

While it may be maintained that such veins cannot supply us with the whole of the materials of the general mass, as the more insoluble cannot be swept from their original position, in virtue of their insolubility, it has to be replied that such rents *do* contain substances usually quoted as types of insolubility. Such are baryte, ilmenite, magnetite, sphene, and quartz itself. More than this, on account of such veins presenting us very generally with giant crystallisations of the several constituents of the rock,—they exhibit these unmistakably, even when no trace of them can be seen elsewhere in the rock.

These plugs of exosmotic transference have the following features which speak to their mode of formation. Their structure is similar on their opposite sides;—they show, more or less perfectly, a series of bands of successive growth. The size of their crystals increases towards their centres, even as regards undue increase in the volume of that extremity of an individual crystal which points to the centre; any vacuous spaces which may occur, lie in the centres of the vein, and into these the free summits of the crystal growths protrude.

A section of such a vein thus forms a marked contrast to that uniformity of size of crystal-grain which gave its name to *granite*. In the latter, the crystallising force latent in each constituent, seems to have been asserting itself in independence, during the time that the rock, apparently as a whole, was rapidly solidifying; and so each substance was interfering with those in contact with it all around its periphery. No perfect crystals could so be formed; and a structure crystalline, but not crystallised, resulted.

In the vein there was no such rush to solidity. There was still self-assertion, as selective cohesion called the molecules of the several individual substances, each to consort with its fellows. There was mutual interference through lateral contact, but free forward extension into—not a vacuous space—but into space filled with a readily displacable fluid. And so there resulted the drawn-out crystallisations, the graphic lettering, and the “capping” of crystals, which are typical of such veins; the individual segregation into large and pure crystals, as if under the dominance of a common polarity, in contradistinction to a confused congeries, in which each crystal seemed to be a law to itself alone. There ensued

the formation of the large crystallisations, so generally obtained from *solution*, as distinguished from the minuter individuals, got by the chilling of masses *liquified by heat*.

But the crystallisations which such veins supply are exceptional, not merely as regards their size and occasionally their regularity of form; they are very much more exceptional as regards the uniformity of their structure;—in other words, their physical and chemical purity. And, therefore, in such may we much more rationally hope to discover optical properties special to each, than in the contaminated individuals which occur in the *mélange* of a rock mass. During the slower process of their formation from watery solution, not only has each molecule ample time to find its way to its appointed place in the crystal fabric, but it has time to evade, instead of sweeping before it to incorporation, any alien substance which may lie in its path. Endomorphs, microliths, and their congeners are hence very much less frequent in the giant crystals of veins, than in those of a rock mass.

As it has in the past been the custom of the chemical mineralogist to glean from this pure source, so should it be the practise of the petrologist to learn the optical properties of the mineral constituents of rocks there also; while it would also be well that he should commence his investigation of rock structure upon slices cut from its veins. Above all would it be well with him if, as the preliminary of all, he called in the chemist's aid to tell him what each substance was that he was looking at. Not till then is he a worker in a *fixed science*;—not till then are his steps *sure*.

The general ignorance in which we all are as regards the optical properties of minerals generally, in *parallel* light, does not appear to the writer, as a mineralogist, nearly so appalling as the self-assured blundering which he has observed among petrologists in this matter. Let us learn our mineralogical *letters*, before we attempt to read the *sentences* in the rocks.

The following are the letters, as determined by analyses, which occurred in a large exfiltration vein, which was found in the Lairg Syenite quarry.

Orthoclase and oligoclase formed the mass of the vein, occurring in nearly equal quantity—the crystals of each being about two inches in length and breadth. Among these were imbedded crystals of *Haughtonite*, of *Allanite*, and of *sphene*. In cracks there also lay a minute quantity of a substance of a purple colour. This much resembled *yttrocerite*, but probably was fluorite; it did not, however, lose its colour when heated.

The orthoclase, which was pale pink in colour, yielded on analysis.

Silica	62·616
Alumina	19·634
Ferrie oxide	·064
Magnesia	·636
Lime	·604
Potash	13·72
Soda	2·92
Water	·13

The oligoclase is frequently imbedded in the little quartz which is present in the vein. It is somewhat more definitely crystallised than is the orthoclase, in which latter it is sometimes partly imbedded, as if of previous formation. It has a yellowish colour, is semi-transparent, but weathers white and opaque. When translucent and quite fresh, it shows striation, but this is not perceptible in the weathered portions. Its cleavage angle is $86^{\circ} 15'$. It yielded

Silica	62.052
Alumina	22.444
Ferric oxide .....	.352
Magnesia .....	.14
Lime.....	4.2
Potash .....	.86
Soda.....	9.22
Water .....	.36
	<hr/>
	99.628

The Haughtonite was present in the elongated crystals which are so common in that mineral, and it had the dark green colour and somewhat flaky appearance which characterise it when slightly weathered. Such weathered crystals also have a greasy lustre, that of the fresh brown crystals being splendid.

It yielded to analysis—

Silica	35.555
Alumina	16.694
Ferric oxide	1.883
Ferrous oxide	18.037
Manganous oxide .....	.694
Lime	2.722
Magnesia	8.472
Potash	9.896
Soda.....	.105
Water	5.714
	<hr/>
	99.722

The crystals of Allanite are elongated, brown black, and here as elsewhere, are surrounded by a brown stain when imbedded in felspar.

The sphenes are, for the most part, ill-defined, dull brown, and earthy, though sometimes clear and lustrous. One crystal in the arrowhead form, which was yellowish, earthy, and soft, was analysed. It yielded

Silica	44.3
Alumina.....	.555
Ferric oxide	7.165
Manganous oxide .....	.7
Lime	1.4
Magnesia	45.91
Water.....	.131
	<hr/>
	100.191

This would, therefore, appear to be a pseudomorph of a substance like olivine in composition.

A study of this syenite, carried out upon the numerous slices furnished me for this purpose by Messrs. Cole & Co., has resulted in a flood of light being thrown upon a structure which I have (in the transactions of the Royal Society of Edinburgh, and in the Mineralogical Magazine) described as occurring in amazonstone; and which is possibly little more than a very pronounced and perfect development of cross-hatching.

The greater number of sections of this rock show plates of orthoclase, the only well-marked features of which are a frequent twining along an interrupted line, and the presence of numerous regular or elongated lozenge-shaped endomorphs. It has also to be noted, that there is not to be seen in the portions of the felspar which show these, or in the felspar when in the position which shows these, any trace either of cross-hatching, or of what I have termed "corded structure." In ordinary light these minute crystals are easily perceived by the sharpness of their edges, and by a slightly increased pellucidity of the slice at the spots where they occur.

In polarised light, they are found to have a feebler depolarising effect than the felspar in which they lie imbedded. Not merely can their marginal edges be seen, but even the edges of their medial planes; and in some they show the form of a plagioclase felspar. For the most part they lie in the same position, both as regards their being bedded in the plate of orthoclase on the face *m*, and in their terminations all pointing the same way. In addition to *m*, they show the faces *p t l* of albite; and that they are plagioclastic is evidenced by the face *p* of one summit always being seen *through* the crystal. From their feeble depolarising power their angle cannot be measured by Leeson's goniometer; but with Ross' I got about $114^{\circ}55'$ as the angle which the edges between *t* and *l*, and *p* and *m* form with each other. From the step-like or in-and-out nature of the composition face of the twin, and from the fact of the imbedded crystals being in an inverted position on the two sides of the line of composition, I conclude that the orthoclase is present in Carlsbad twins, and that the endomorphs rest with their faces *m* parallel to the face *a* of the twin.

The chief interest connected with these minute crystals lies in their relationship to the "cross-hatched" structure. In the slices or portions of the slices which show the latter structure, there is no appearance whatever of any of these crystals, in a recognisable form; yet from their frequency they must be present in the slice. I have shown elsewhere that this structure is seen in slices parallel to *c* of orthoclase; and that the wedge-shaped crystals which form it, lie parallel to *b*, and "are transversely barred or broken up, as if themselves built up of myriad crystals."

We see, both in the amazonstone of Tongue, and in the cross-hatching here, that the *bars* are of feeble depolarising power; and we know that minute flat crystals disposed parallel to *a*, would be at right-angles to *c*; and hence would cross-cut flat crystals, which lie parallel to *b*. Taking the above into consideration, we may conclude that these crystals form part of the structure in cross-hatching, and that the special part is probably that arm of the cross which lies parallel to *a*.

The hornblende of this Syenite is seen in these slices with three appearances. We have it in flat green foliations of its dominant cleavage parallel to m : in sections at right angles to the last, showing the m cleavages as lozenge shaped diagonal cleaved patches, generally brownish in tint; and, lastly, in patches of a greyish tint, polarising more feebly. These last are sprinkled with dotted markings, resulting apparently from a diagonal sectioning which cross-cut the apices of the lozenge cleavages.

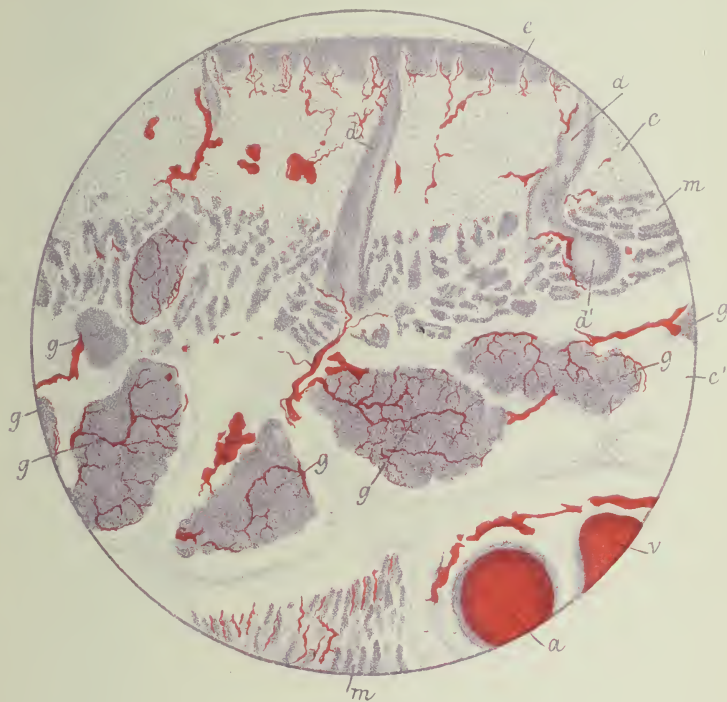
The Haughtonite, cut transversely to its foliation, is brown opaque under-crossed Nicols, and greenish olive with parallel Nicols. It is plentifully sprinkled with crystals of apatite, which are generally disposed between the plates of the mica. These also cut the structure of the hornblende in all directions. When the foliations of the Haughtonite lie parallel to the section, they have a rich oily colour, thinning off in intensity towards the fringes; and a softly lineated central surface, the lineation being irregular in its disposition, like sea waves.

The oligoclase is present in much smaller crystals than is the orthoclase. It is in crystals twined on the face m , but generally with a slight imperfection in apposition; so that the striation of the two halves is not equally well seen at the same time. It rarely contains the minute crystals. These, in it, are disposed at right angles to the striation.

The crystals of oligoclase are imbedded in the quartz, and also are sometimes enveloped by the orthoclase. These never contain the minute crystals of supposed albite. The style of their striation is very simple. They are banded from end to end with a striping which is uniform in width, uniform in its two tints, and unbroken. The tints shade off into one another by a diffused medial zone,—there being no sharp demarcation, and no angular interruption longitudinally.

No spheenes appear in the slices examined. They will be recognisable by their section showing acute angles on one or other side, by their yellow-brown colour, and by a style of fissuring much resembling that of augite.

The quartz is unusually pervaded by fluid cavities in linear arrangement.



Ad. ad nat.

T. S. ŒSOPHAGUS OF DOG.

Injected & Stained

X 65

Hest. Newman del. 1880

THE ALIMENTARY CANAL.¹

THE TONGUE.

Etymology.—TONGUE (tǔng), *n.* [A.-S., L. Ger., and Dan. *tunge*, O. Sax. *tunga*, *tunge*, O. Fries. *tunge*, *tonge*, D. *tong*, Icel. and Sw. *tunga*, Goth. *tuggō*, O. H. Ger. *zungī*, N. H. Ger. *zungē*; Ir. and Gael. *teanga*, *teangailh*; O. Lat. *lingua*, afterward *lingua*.]

Anatomy.—"The tongue is a muscular organ covered with mucous membrane. By its muscular structure it takes part in the processes of mastication and deglutition, and in the articulation of speech, while its mucous membrane is endowed with common and tactile sensibility and is the seat of the sense of taste. The tongue occupies the concavity of the arch of the lower jaw; posteriorly it is connected with the hyoid bone, and the back part of its upper surface forms the floor of the arch of the fauces; inferiorly it receives from base to apex the fibres of the genioglossus muscle, and through the medium of that muscle is attached to the lower jaw."²

EXPLANATION OF PLATES.

HUMAN TONGUE.

Papillar Surface with Fauces and Tonsils.

(SAPPEY.)

1, 2, Circumvallate papillæ; in front of 2, the *foramen cæcum*; 3, Fungiform papilla; 4, Filiform and conical papillæ; 5, Transverse and oblique ranges; 6, Mucous glands at the base of the tongue and in the fauces; 7, Tonsils; 8, Part of epiglottis; 2, Median glosso-epiglottidean fold or *frenum epiglottidis*.

THE TONGUE.

Papillæ, Glands, etc.

FIG. I.—*Two Filiform Papillæ, one with Epithelium; the other without* (After TODD and BOWMAN). *p.* The substance of the papillæ divided at the upper extremities into secondary papillæ; *a.* Artery, *v.* Vein, connected by capillary loops; *e.* Epithelium, laminated between the papillæ but extended into hair-like processes; *f.* The extremities of the secondary papillæ.

FIG. II.—*Superficial and Sectional Views of a Fungiform Papilla* (After TODD and BOWMAN).

¹Continued from p. 264.

²QUAIN'S *Elements of Anatomy*, London, 1876, Vol. ii, p. 325.

A.—The surface of a fungiform papilla partially divested of its epithelium, $\times 35$ diameters, *e*. Epithelium, *p*. Secondary papillæ.

B.—V.S. of a fungiform papilla with its blood-vessels injected. *a*. Artery, *v*. Vein, *c*. Capillary loops of simple papillæ in the neighbourhood, covered by the epithelium; *d*. Capillary loops of the secondary papillæ; *e*. Epithelium.

FIG. III.—*A Circumvallate Papilla from the Human Tongue*. A. With accessory papillæ *c*, its epithelium *a*, and nervous twigs *b*. B. The ridge running round the papilla, with its nerves *b* (TODD and BOWMAN).

FIG. IV.—*Plan of a Lingual Follicle*. *a*. Hollow reduplication of the mucosa with its papillæ; *b*. Lymphoid portion of the walls with several follicles (FREY).

FIG. V.—*Tonsil of an Adult*. *a*. Large excretory passage, *b*. A simple one, *c*. Lymphoid parietal stratum with follicles, *d*. A lobule strongly resembling a lingual crypt; *e*. A superficial, *f*, a deeper mucous gland.

V.S. TONGUE OF DOG.

Circumvallate Papilla $\times 65$ diameters.

The papilla exhibits a median primary division, and each eminence thus formed shows minute secondary papillæ. *v*. The vascular mucosa; the spaces represent sections of capillary vessels. *e*. Stratified squamous epithelium; at the basis of the papilla the taste goblets *t* are shown. *s*. Serous glands which open at the base of the papilla. *d*. Duct of serous gland. *m*. fasciculi of striated muscle cut lengthways. *m'*. T. S. of fasciculi of striated muscle, showing perimysial connective tissue. *f*. Submucosal fat

DESCRIPTION.

Although the mucous membrane of the tongue is in direct continuity with that of the oral cavity, it differs from the latter in several respects. On the dorsum of the tongue, the mucous membrane is raised up into characteristic papillæ which have been termed *filiform* and *fungiform* after their respective shapes, and is comparatively thin and firmly attached to the underlying muscular tissue. At the base of the tongue it becomes thicker, and through its lax arrangement, is thrown into complex definite folds and corrugations.

The epithelium consists of a layer of stratified squamous cells like those of the oral cavity, but since it follows the boundary line of the more marked papillæ on the dorsum, its deepest layer of columniform cells is placed at right angles to the papillar surface. On the lower, the epithelium forms a thinner stratum than on the upper surface of the tongue.

The mucosa is composed of a tissue which is precisely similar to that of the oral cavity. Its upper portion is raised up into two kinds of papillæ. (i.) The *papillæ filiformes*; these may be simple or compound. In the latter instance a common base subdivides into two, three, or more prolonged eminences. Whether simple or compound each primary division gives rise to many secondary projections, and the epithelium covering these may form many

elongated filamentous groups. In most mammals the cells of these filaments become horny and fused together. (ii.) The *papillae fungiformes* consist of mushroom-like prominences from which numerous minute secondary papillae project; the whole is covered by a layer of stratified squamous epithelium which obscures the subjacent secondary papillae. The blood-vessels form a well marked network in the substance of the mucosa, and the general lymphatic system is essentially the same as that in the oral cavity. The variety of fungiform papilla termed *circumvallate* (owing to the development of a large papilla around which the mucous membrane dips down to form a kind of trench), are further distinguished by their rich nervous medullated fibrillae; they are doubtless intended to supply the organs of taste, which these papillae support, and according to KRAUSE¹ the distribution of those organs coincides with the ultimate ramifications of the glosso-pharyngeal nerve.

In the root of the tongue, where the mucous membrane is comparatively loosely arranged, the latter is pervaded by many secretory and lymphoid structures.

The secreting apparatus pertains in the form of *mucous* and *serous* glands (v. EBNER²). The mucous glands resemble both in structure and position those which obtain in the general oral cavity³; they do not occur in the immediate vicinity of the organs of taste, but are found in every other part of the tongue, as at the margins and apex of its dorsum (BLANDIN⁴). In man the epithelium at the commencement of the ducts, is occasionally ciliated (v. EBNER²). The serous glands may always be detected in the neighbourhood of the taste organs, and open by funnel-shaped ducts into the trenches which surround the circumvallate papillae or other papillae containing taste buds. In structure they are in miniature what the true salivary glands are on a larger scale.⁵ Their secretion, too, is watery; they are thus enabled to fulfil the function of rapidly distributing the substances to be tasted over the gustatory organs more efficiently than if they produced a viscous secretion (v. EBNER²).

The taste organs were discovered in the *Mammalia*, independently, by LOVEN⁶ and SCHWALBE⁷; they were already known to exist in the *Amphibia* as intercalary patches amidst the epithelium of the dorsum and margins of the tongue (Billroth⁸, HOYER⁹, AXEL KEY¹⁰, ENGELMANN¹¹.)

In mammals they obtain as rows of ellipsoidal bodies at the base of the circumvallate papillae, and in some other fungiform papillae. They are also developed in three or four closely packed rows in the permanent side folds of the *papilla foliata*, situated laterally and at the base of the

¹Göttinger Nachrichten, 1870.

²Die acin. Drüsen der Zunge, 1873.

³Ut supra, pp. 262-263.

⁴Arch. Gén. de Méd., 1823.

⁵Ut supra, p. 246.

⁶Archiv für mikr. Anatomie, 1867.

⁷Archiv für mikr. Anatomie, 1868.

⁸Archiv für Anat. und Physiol., 1858.

⁹Archiv für Anat. und Physiol., 1859.

¹⁰Archiv für Anat. und Physiol., 1861.

¹¹Zeitschr. für wissen. Zoologie, 1867.

tongue of man and many other mammals. The papillæ foliatæ are especially conspicuous in the tongue of the rabbit, where they form two lenticular patches of considerable size, one on each side. HOFFMANN has also detected them in certain papillæ on the soft palate, and has also pointed out that single buds occur on the summits of some fungiform and circumvallate papillæ in man,—a fact hitherto denied. Their ellipsoidal form has given rise to the term *taste goblet*, by which they are universally known.

The taste goblets lie embedded in the epithelium of the papillæ in such a manner that their major axes point at right angles to the surface of the mucosa; one pole abuts against that structure, whilst the other reaches the free boundary of the epithelium. The epithelial cells in immediate contact with the goblets become imbricated to produce an investing layer.

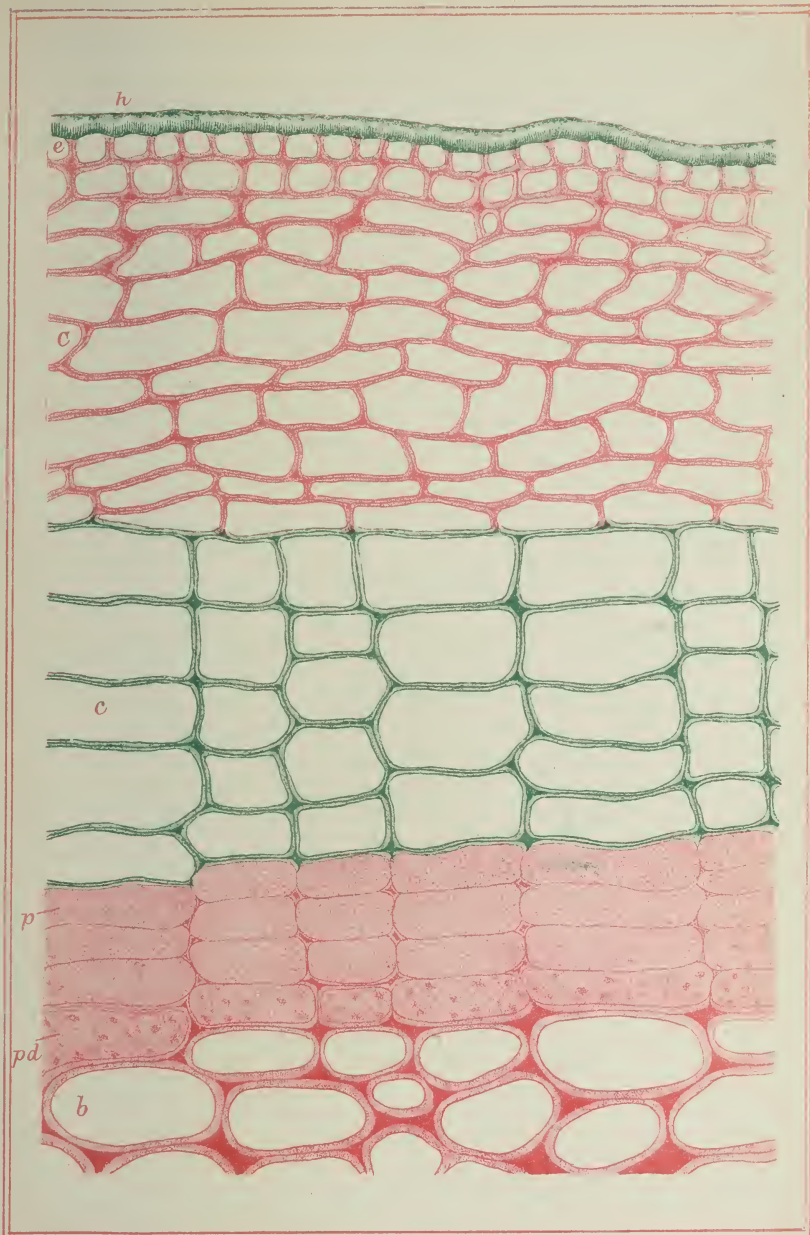
Each goblet consists of an outer layer of cells, termed *peripheral* or *tegmental* (SCHWALBE¹, LOVEN¹); so arranged as to produce the ellipsoidal outline; the cells are elongated, slightly flattened, and fusiform, each with a sub-central flattened or oval nucleus; they are sometimes branched (SCHWALBE¹). Within the peripheral there occur the *central* or *taste* cells (ENGELMANN²); these are delicate fusiform or staff-shaped cells which terminate at both ends in filaments, and possess centrally placed spherical nuclei; their outer processes project slightly beyond the orifice at the free extremity of the goblet formed by the peripheral cells, whilst their inner ends, which are sometimes finely bifid are directed to the subjacent mucosa. Many nerve fibres penetrate to this region, and have been shown by ENGELMANN and HÖNIGSCHMIED to be directly continuous with the taste cells.

The lymphoid structures of the tongue are situated in the mucosa, and from thence extend upwards as diffuse adenoid tissue to the epithelial strata. They occur chiefly at the posterior part of the organ, and may either obtain in the form of nodular aggregates, known as *lymphoid follicles*, or these may become invaginated to produce the so-called *lymphoid recesses* or *crypts*, into which the ducts of secreting glands may also open.

The folds of the oral mucous membrane which form the two prominent bodies known as tonsils, situated one on each side of the fauces, are composed of lymphoid follicles arranged somewhat after the fashion, (but more extended), of those in the mucosa of the tongue. Each tonsil is composed of a mucosa surmounted by a layer of stratified squamous epithelium, as at other parts of oral cavity; its mucosa, however, contains so many closely placed spherical or ovoid masses of adenoid tissue, that it is thrown into many folds, which thus acquire the aspect of numerous crypts placed side by side. The adenoid tissue of the follicles becomes somewhat diffused in their immediate neighbourhood, and often encroaches on the overlying epithelium, which may in this manner ultimately give way to the retiform tissue and its corpuscles. Hence it often happens that the latter find their way into the saliva of the oral cavity and then become the so-called mucous or salivary corpuscles.

¹*Op. cit.*

²*Stricker's Handbook* 1870.



J. del. ad nat.

West, Newman & Co. lith.

RIBES NIGRUM

T.S. of Stem.

Showing the formation of Cork.

X 500.

RIBES NIGRUM.

(THE BLACK CURRANT.)

T.S. of Stem-stained in Carmine and Aniline Green.

× 500 diameters.

h. Epidermal hair, *e.* Epidermis, *C.* Distorted cortex, *c.* Cork cells (Periderm),
p. Phellogen, *pd.* Phelloderm, *b.* Bast-fibres.

Etymology.—*RĪBES*, *n.* [So named by LINNÆUS from the Arabic word for *Rheum*, wrongly applied to this genus] (HOOKER¹).

NĪGRUM, [Lat. *niger*, black, on account of the colour of its ripe fruit.]

DESCRIPTION.

The stem of the black currant has been chosen in illustration of the development of cork in the cortical region. The illustration is intended to portray that growth, and shows the corky formation very clearly through the differentiation of the carmine and aniline green. The epidermis has been stained green, and the product of the phellogen or *periderm*, which has become thoroughly suberised, is marked off sharply from the superjacent cortex and subjacent phellogen by being stained brightly green, whilst the other parts have been tinged with red.

The hard and soft bast are both coloured red, and lie between the phelloderm (also coloured red), and the xylem; the latter absorbs the green dye except towards the central parenchyma, where the medullary annulus of spiral vessels has a tendency to be coloured red. With a power of about 300 diameters the medullary rays may be traced at intervals in the xylem zone, traversing that region radially; they may be distinguished by the cuboid form of their thinned-walled cells arranged in rows, and by their absorption of some of the red pigment. It sometimes happens that individual specimens vary slightly from each other, some of them appropriate more of the red, whilst others affect a greater partiality for the green dye.

The central parenchyma consists of polygonal conical thin-walled cells united into an areolar reticulum, the lacunæ of which, formed by the intercellular spaces, produce a system of large cylindrical branched canals throughout the tissue.

¹The Student's Flora, 2nd Ed., London, 1878, p. 140.

ON THE FORMATION OF CORK.

The *suberous*, *cuticular* or *corky* change, consists of a chemical transformation of the cellulose of the cell walls, either wholly or in part, and is accompanied by certain physical peculiarities.

By a process of secretion the cell-wall is produced from the protoplasm, and is composed almost entirely of cellulose; as the cell grows, its wall increases in bulk at the expense of the cell contents, until eventually the latter vanish altogether; during these processes the walls of those cells which are destined to perform the functions of protective coverings, become chemically transformed. The original cell-wall is hyaline, absorbs water readily, is only slightly extensible and elastic, and when treated with sulphuric acid and iodine, turns blue, whilst the cuticularised structure is highly extensible and elastic, does not imbibe water readily, and turns yellow when acted upon with sulphuric acid and iodine. The addition of SCHULTZ'S solution¹ has the effect of turning ordinary unchanged cellulose blue, whilst cuticularised products remain colourless or are tinged yellow.

The physical properties of cork, its extensibility and elasticity, and its power of resisting the penetration of air and water, peculiarly adapt it to perform a protective function. When the succulent members of the higher plants are injured in any way, the healing process is effected by the cuticularisation of the cells near the wounded surface which subdivide and form a membranous expansion to intervene between the injured part and the living tissue; the cells above this membrane become desiccated, and the surface is then covered with a protective layer of cork.

In Mexico and the Canaries, where the prickly pear, *Opuntia vulgaris* and its allies are cultivated for the purpose of rearing the Cochineal insect (*Coccus Cacti*), recourse is had to the multiplication of plants by cuttings. The pieces of cactus are exposed in a dry place to the sun for about a month, until the wounded surface is healed by the formation of a superficial layer of cork; this prevents the decay of the cutting, which inevitably follows when it is planted before a protective coat is formed. The healing over of larger wounds, especially in woody plants, is effected only partially by the formation of cork; chiefly by an *overgrowth* of cells of the meristem portion of the branch; *callosities* also are due to similar developments, and are not to be attributed to peridermal growths.

Closely allied in histogenetic changes to the process of healing, is that which takes place previously to defoliation. In most woody plants, the approach of autumn in the temperate zones, causes the leaves to be shed. A peculiar change takes place at the base of the leaf, whereby a special band of tissue is produced, which splits along a plane between the common cell walls, so as to leave the latter uninjured; the next process consists in the suberisation of the cells contiguous

¹The following formula for this solution, given by HUXLEY, (*A Course of Elementary Instruction in Practical Biology*, London, 1877, p. 270), is the best:—"Dissolve some zinc in hydrochloric acid, permit the solution to evaporate, in contact with metallic zinc until it has attained a syrupy consistence. Saturate the syrup with potassic iodide, and then add enough iodine to make a dark sherry-coloured solution. The object to be stained must be placed in a little water, and then some of the above solution added."

to the surface, and the scar is thus effectually protected from the severity of the winter. These changes may be easily made out in the winter bud of the ash (*Fraxinus excelsior*), which is large, and terminates in a very compact apical bud covered over by protective scaly leaflets; at the base of the bud two leaf scars obtain. A median longitudinal section taken through the entire terminal bud, and made to include the scars, shows the formation of cork over those regions, and its union at each edge with the periderm of the branch.¹

Cuticularisation, which is one of the earliest conditions of the corky change, is also one of the most universal in the vegetable kingdom. It is initiated in the rudimentary forms of plants as a condensation of the outermost zone of the cell wall; it asserts itself more definitely in the spores of cryptogams. In the germinative process, the exospore which becomes cuticularised, separates from the endospore, which continues to develop, and is, therefore, no longer required as a protective member; both exospore and endospore exhibit a peculiar laminated structure, which is to be attributed to special physico-chemical differentiations of their substance.

In the pollen grains of the higher plants, the extine is distinctly cuticularised, and on germination is ruptured by the unaffected intine. The action of potassium hydrate solution (five per cent.) or of concentrated sulphuric acid, has the effect of changing the extine red, whilst the intine in the first case swells and remains colourless, and in the second instance is dissolved away.

The cuticular change is still more marked in the epidermis of the higher plants. In the mistletoe (*Viscum album*) the peripheral portions of the epidermal cells are enormously thickened, and their outermost boundary unites to form a cuticular membrane. In the holly (*Ilex aquifolium*) the cuticularisation is very complex. According to SACHS², if the under surface of a very thin transverse section, taken through the central vein of the leaf, is examined under a power of about 800 diameters, after having been subjected to the reaction of SCHULTZ's solution, the following characters may be identified. The cell wall of the epidermis of each cell is seen to consist of two layers of which the inner one which is soft and more capable of swelling turns blue, and therefore gives the reaction of cellulose, whilst the firmer outer zone is but slightly affected, and thus shows its cuticular nature; this layer moreover, exhibits a differentiation into two parts; an outer, which remains colourless and forms the cuticle proper, and an inner portion which becomes yellow and passes laterally between the cells. Between these two a boundary zone exists, which, when the microscope is focussed to it, appears as a shadow over the other two layers. Both the inner (blue) and outer layers are stratified; whilst the outer zone still further exhibits a radial cross-hatching, due to the development of its penetrating bands which are coloured yellow; these were formerly and

¹ The winter bud of the ash, if cut as directed above, and doubly stained, makes not only a very beautiful preparation, but an especially instructive one. The vernation holds compactly together, and the apical region is large and well defined.

² *Text-Book of Botany*, Oxford, 1882, p. 34.

erroneously considered to be pores, but are now known to consist of the radially disposed particles of a substance of different constitution; viewed from above, along the length of the leaf vein, they present the appearance of longitudinal striæ which pass over the septa of the cells.

The development of cork is most marked where the formation takes place in the cortical parenchyma of the plant. A good typical example is to be found in the subject of this description (*Ribes nigrum*); here, it is best to choose a one-year old branch at the end of summer, when the green hue of the stem has changed to brown. The epidermal layer with its cuticular border, still forms the external liminary layer of the structure, and the growth of the cork may be noticed in the cortex. Deep down in the cortex, almost in contact with the phloëm, a ring of from two to three cells deep of meristem tissue may be observed; these cells are of parallelopipedal forms and are closely apposed to one another; they do not exhibit intercellular spaces. The proliferation of these elements takes place by tangential division, but also sometimes in a radial direction; the resultant cells pass upwards towards the epidermal region, and in doing so become suberised. Thus, in the course of time, a zone is formed of lamellæ of cells, which, in transverse section, present oblong outlines; to these layers collectively, the term *periderm* is applied, and the actively growing zone which produces it, is termed the *phellogen*; the cork or periderm then, is produced *centrifugally*. But the phellogen also develops *centripetally*,—it produces a layer of chlorophyll containing cells which come to lie between it and the bast fibres of the phloëm; to this zone SANIO has given the name *suberous cortical layer* or *phelloderm*. The continued formation of periderm causes the cortical tissue above it to become much compressed and distorted and eventually to rupture and desquamate.

On rare occasions the epidermis gives rise to a phellogen, as in the *Pomaceæ* and in *Salix*; more often, however, as in one year old branches of *Pinus sylvestris*, a layer which closely resembles the epidermis is formed from the uppermost stratum of cortical cells, and looks like a second epidermal layer.

The epidermis is eventually replaced by the cork, especially in succulent stems; in the tubers of the potato the epidermal tissue cannot keep pace with the rapid growth of the structure, and its place is therefore taken by the elaboration of a corky layer from the superficial cortex.

Most commonly, the development of the periderm takes place towards the end of the summer, of one year shoots, and may be termed *primary*. It is entirely absent in the mistletoe and in a species of maple (*Acer Pennsylvanicum*); in *Enonymus* it appears in branches only after many years of their growth; it is usually developed from a deeply seated portion of the cortex, and sometimes even in the bast, as in the grape vine.

The formation of a corky layer within the epidermis sooner or later causes the superjacent structures to dry, and to be thrown off from the economy of the plant as *bark*. In the root, the whole of the cortex is gradually desquamated in this way, on account of the development of the primary periderm from the pericambial zone.

The growth of the primary periderm from the superficial cortex or epidermis, may continue unabated for a protracted period of time, and may accumulate to form large masses of cork, as in the cork oak (*Quercus suber*). An examination of this cork shows an alteration of layers of dense and loose cells; in the case of the birch (*Betula alba*) these layers may be readily peeled off. In other instances (e.g., the maple, *Acer compestre*), the cork is raised up in longitudinal conical ridges from the angles of the branches. This primary cork continues for several years; in some plants, its outer layers are constantly thrown off and replaced from within by the proliferation of the phellogen; this is the permanent condition in the beeches (*Fagus sylvatica*, *cuprea*, etc.)

Later in the life history of the plant comes the development of *secondary periderm*; this originates deep down in the layers of the stem; it is sometimes formed at intervals, at other times it occupies the whole circumference of the structure; in the former instance, as soon as it comes into contact with the primary periderm, that structure, in obedience to the law which provides for the formation of bark, becomes detached in scales and patches which crack from without inwards along the lines of least cohesion; these scales may be shed, as in the plane, (*Platanus orientalis*), or they may remain attached to the surface of the plant, adherent one upon the other, as in the pines. In Robinia they remain connected in long strips by the bast fibres.

Where the secondary periderm is uniformly developed, its approach to the surface causes the primary periderm to give way in the form of ringed bark, which detaches in annular layers, as in the cherry, (*Prunus Cerasus*), or splits off in long strips (due to the enclosure in it of bast fibres) as in the vine, thuja, etc.

In the monocotyledonous *Dracena*, and in the rhizome of *Ophioglossum* (Russow¹) a superficial layer of cork is formed, and are examples of exceptional occurrence in those sections of the vegetable kingdom.

It is one of the characteristics of periderm that its tissues do not exhibit intercellular spaces, but during the summer months especially, the periderm in the region of the epidermal stomata in shoots of the first year, exhibit peculiar wart-like spots, termed *lenticels*; these spots sometimes become enormously widened through the rapid increase in thickness of the stem, as in the birch. In structure they consist of areas of loosely arranged cork cells, with intercellular spaces, which permit of the entrance of air to the subjacent living cortical tissue. The formation of cork is usually initiated at these spots, and when it becomes considerably developed, as in the cork-oak, the central portion of the lenticels form passages filled with a mass of loose cells.

METHODS OF PREPARATION.

The method of staining in carmine and aniline green has already been fully detailed².

OLIVIER'S METHOD³.—Steep the sections in a solution of *fuchsin*, made with equal parts of alcohol and water; the sections must thereafter be

¹*Vergleich. Unters.*, St. Pétersbourg, 1872, pp. 117, ff.

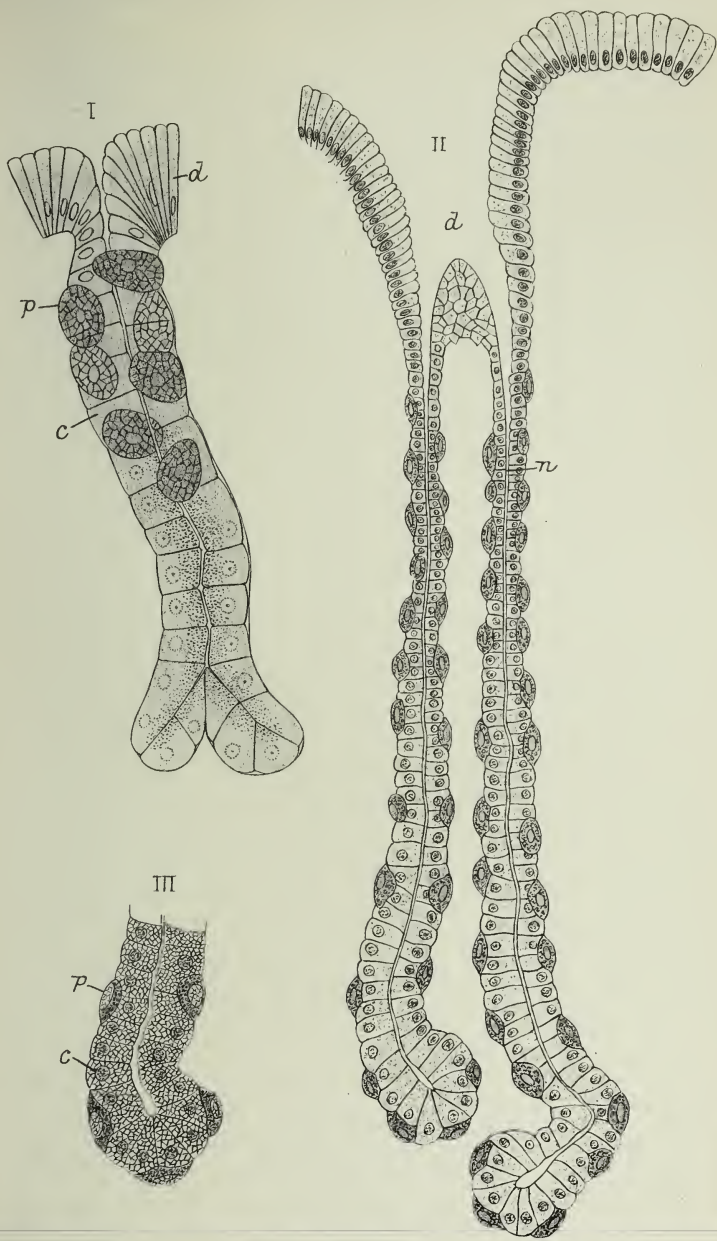
²*Ut Supra*, pp. 14-16.

³*Bull. Soc. Bot. France*, 1880, T. xxvii, pp. 234-5.

washed in absolute alcohol. It will be found that the suberised cells retain the red colour of the dye, whilst the cellulose portions discharge it entirely, and remain colourless.

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THE STOMACH.

- Fig.I. Cardiac Gland of Bat (Langley) x 420.
 Fig.II. Cardiac Gland of Dog. (Klein) x 350.
 Fig.III. Cardiac Gland of Dog. (Klein) x 450.

THE ALIMENTARY CANAL.¹

THE PHARYNX.

Etymology.—PHAR'YNX (fär'yinks), *n.* [Gr. *φάρυγξ φάρυγγος*, Fr. *pharynx*, It. and Sp. *faringe*.]

Anatomy.—"The pharynx is that part of the alimentary canal which unites the cavities of the mouth and nose to the œsophagus. It extends from the base of the skull to the lower border of the cricoid cartilage, and forms a sac open at the lower end, and imperfect in front, where it presents apertures leading into the nose, mouth, and larynx."²

DESCRIPTION.

In minute structure the pharynx admits of a two-fold division into an upper and a lower portion which pass by gradual transitions into one another, and into the respective passages with which it is connected.

The mucous membrane of the upper section, which leads to the respiratory organs, is lined by a stratified layer of columnar epithelial cells, the most superficial of which are ciliated. The mucosa is beset with numerous crypts and folds of adenoid tissue, which is arranged after the manner observed at the root of the tongue and the tonsils, diffuse and in follicles, and led LUSCHKA to term it the "*pharyngeal tonsil*," the pits and crypts of which he describes as lined with ciliated columnar epithelium. GANGHOFNER,³ in his paper on the tonsils and *bursa pharyngis* of children, has marked out one portion of the last named structure, to which he has applied the name "*recessus pharyngis medius*," in which ciliated columnar cells alternate with stratified squamous epithelium; the latter is usually developed on the folds of the mucosa, it also obtains in form of small patches every here and there amidst the ciliated epithelium.

The lower and most extensive division of the pharynx is essentially similar in minute structure to the rest of the oral cavity, a detailed description of which has already been given.⁴

THE ŒSOPHAGUS.

Etymology.—Œ-SOPH'A-GŪS (e-sŏf'a-gŭs), *n.* [Gr. *οἰσοφάγος*, from *οἶσω*, future of *φέρειν*, to bear, to carry, and *φαγεῖν*, to eat.]

Anatomy.—"The *œsophagus* or gullet, the passage leading from the pharynx to the stomach, commences at the cricoid cartilage, opposite the

¹Continued from p. 274.

²QUAIN'S *Elements of Anatomy*, London, 1878, vol. ii, p. 341.

³*Über d. Tonsilla und Bursa pharyngea, Sitz. d. k. Akad.*, Wien, 1878, Bd. lxxviii.

⁴*Uti supra*, pp. 261—264.

lower border of the fifth cervical vertebra (sixth, BRAUNE), and descending along the front of the spine, passes through the diaphragm opposite the ninth dorsal vertebra, and there ends by opening into the cardiac orifice of the stomach¹."

EXPLANATION OF PLATE.

T. S. ŒSOPHAGUS OF DOG.

Injected and Stained.

× 65 diameters.

e, Stratified pavement epithelium. *c*, Connective tissue of the mucosa showing numerous small papillæ. *m*, Muscularis mucosæ, composed of many bundles of non-striated muscular fibres. *c'*, Submucous connective tissue, which lodges the mucous glands *g*; these open on to the surface by means of vertical or obliquely-disposed ducts *d*. *d'*, Transverse section of a duct. *m'*, Striped muscular fibres of the circular muscular coat. *a*, Artery, *v*, Vein in the submucous connective tissue.

DESCRIPTION.

The stratified squamous epithelium which characterises the mucous membranes of the oral cavity and lower pharynx of mammals, is continued over that of the œsophagus in those animals, and is especially well developed in man. The underlying mucosa, which also resembles that of the oral cavity in minute structure, is raised up into numerous conical papillæ of variable size, which attain their maximum in the human subject. Beneath the mucosa a layer of non-striated muscular fibres obtains and forms the *muscularis mucosæ*; the fibres are arranged in longitudinal fasciculi of larger and smaller sizes. At the commencement of the œsophagus they are small and separated by a large amount of connective tissue, but they increase in size and number towards the end of the organ, and eventually form a closely set continuous zone. The mucosa and muscularis mucosæ are most largely represented in the *Carnivora*; in the case of the dog the latter is composed of many fine fasciculi connected into a plexus. This is well marked in the illustration where the bundles are shown transversely cut, and very often surround some of the mucous glands which ordinarily lie in the submucosal region.

The submucous tissue contains the mucous glands; in details of structure it is similar to the corresponding layers in the oral cavity. The mucous glands exhibit the same structure and phenomena during normal, stimulated, and exhausted conditions, as the glands of the oral cavity. LANGLEY and SEWALL² have pointed out that the œsophageal gland cells are occasionally beset with clumps of highly refractive granules in their peripheral portions; these "*border granules*" as they termed them, are different from the ordinary cell granules; they are very constant in position, and the reaction of osmic acid shows them to be fatty globules. In the human subject they are but sparingly developed, but, in the *Carnivora*

¹QUAIN'S *Elements of Anatomy*, London, 1876, vol. II, pp. 343, 344.

²*Proceedings of the Royal Society*, London October, 1879, p. 383; *Journal of Physiology*, 1879, Vol. ii, p. 283.

especially in the dog, the glands are very abundant and well defined. They extend throughout the upper two-thirds, or even more, of the submucous tissue, and in some cases penetrate the region of the mucosa; but in every such case, it may be observed with a high power of the microscope that the gland alveoli are entirely enveloped in a layer of loose connective tissue, similar to that of the submucosa, and is never really embedded in the mucosa proper. The ducts of the mucous glands pass through the muscularis mucosæ and the mucosa in a vertical or oblique direction, and open by narrow mouths on to the surface of the epithelium either between the papillæ or at their summits. The epithelium of the ducts is essentially similar to that described in the ducts of the mucous glands of the oral cavity.

With reference to the glands of *Rana temporaria*, J. N. LANGLEY¹ says:—"I apply the term *simple* tubular to such glands as consist of one tube; when several tubes are given off by one duct, I call the glands *compound* tubular; when the tube or tubes arising from a duct divide, I call the gland a *complex* tubular gland." The œsophageal glands of *Rana temporaria* are complex tubular, those of the dog are of the compound tubular type, as in most other mammals.

The submucous tissue is supported externally by the muscular tunics of the organ. In man, these consist of two coats, an inner circular and an outer longitudinal. The circular exceeds the longitudinal coat in thickness at all parts of the œsophagus, except its upper fourth. The fasciculi of muscles are separated by a fibrous connective tissue, which is a continuation of that of the submucosa. In the upper half of the first fourth, the muscular coats consist of striated fibres; in the second half these are mixed with non-striated fasciculi, and the latter increase gradually amongst the former, until the middle of the œsophagus is reached; after that, striated fibres cease to exist, and the entire tunics are composed of non-striated muscle cells. In other mammals, however, the striated persist amidst the unstriped elements up to the cardiac end of the stomach; the division into a circular and a longitudinal coat, also is less marked, and a third coat is often found, or the entire muscular zone may become spirally arranged.

Outside the muscular coat a thin zone of fibrous connective tissue with its fibres more or less longitudinally disposed, bounds the walls of the œsophagus.

THE BLOOD-VASCULAR SYSTEM.—Both in the pharynx and œsophagus the arterial twigs situated in the submucous tissue give off branches, which proceed through the muscularis mucosa to the upper zone of the mucosa, where they form a capillary network; from these loops are given off to the papillæ. From the capillary meshwork in the mucosæ the veinlets convey the blood through the mucosæ and muscularis mucosa to the venous trunks which lie in the submucosa. The muscularis mucosæ the mucous glands, and the external muscular coats possess blood-vessels of their own.

¹*On the Histology and Physiology of Pepsin forming Glands*, Phil. Trans. Roy. Soc., London, 1882, p. 664.

THE LYMPHATIC SYSTEM.—The distribution of the lymphatics resembles that which has been described with regard to the oral cavity, our knowledge of which is chiefly due to the investigations of TEICHMANN.¹ In the pharynx and œsophagus KIDD has shown that the lymphatics and lymph sinuses of the mucous glands are connected with the lymphatic system of the submucous tissue.

THE NERVOUS SYSTEM.—The œsophagus is surrounded by a plexus of large nerve trunks, which contain many ganglia (REMAK). According to KLEIN², "The nerve-branches that enter the œsophagus form a dense plexus of smaller or larger bundles between the circular and longitudinal layer of the external muscular coat. In these nerve branches we meet with isolated, or chains of ganglion cells (KLEIN); each of these is enclosed in a capsule. The submucous tissue contains another plexus of nerves, connected with the former plexus, and in this also isolated ganglion cells sometimes obtain (KLEIN)."

METHODS OF PREPARATION.

The specimen from which the illustration was taken was injected with a carmine-gelatine mass through the aorta of a freshly killed small dog, and hardened in strong methylated spirit.³ The œsophagus may also be hardened in chromic acid and spirit solution, but this is liable to dissociate its muscular coats.

¹*Das Sangadersystem*, 1861.

²*Atlas of Histology*, London, 1880, p. 203.

³For a full description of the methods of preparing the injection mass, and the hardening, and staining of sections, see this Journal, pp. 85, 219, etc.

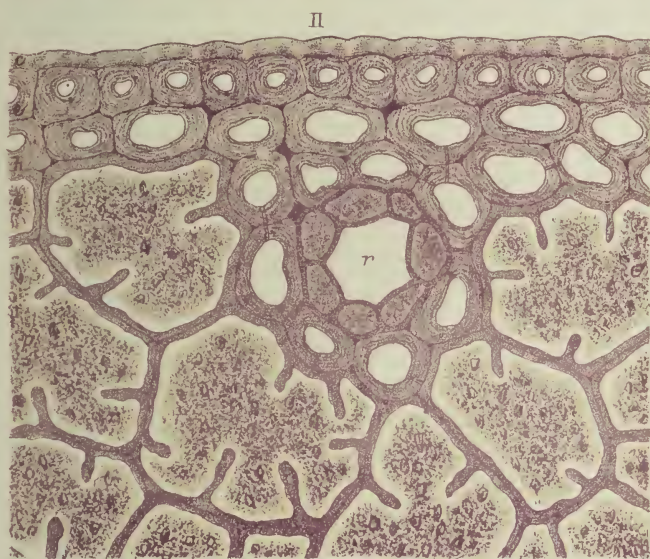
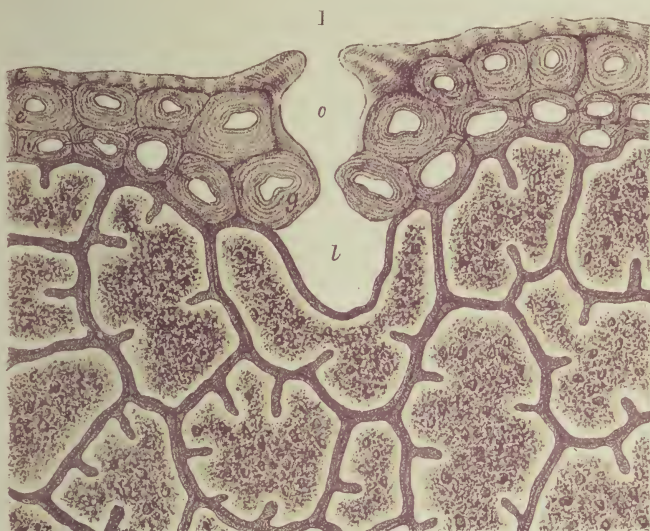


Fig. del. ad nat.

Wet. Newmark's. 1878.

PINUS SYLVESTRIS

Transverse Section of Leaf.

Fig I. Through a Stoma. Fig II. Through a Resin passage

PINUS SYLVESTRIS.

THE SCOTCH FIR.

T. S. of Leaf, Stained Logwood.

Etymology.—PINUS, *n.* [Lat. *pinus*, allied to Gr. *πίτυς*, A-S. *pinu*, *pinntréo*, D. *pijn*, *pijnboom*; Fr. and Pr. *pin*, Sp. and It. *pino*]. (*Botany*).—A tree of the genus *Pinus*, belonging to the tribe *Abietineæ*, and order *Coniferae*.

SYLVESTRIS.—[Lat. *sylvā*, *silva*, a wood or forest, a quantity, a crowded mass].

EXPLANATION OF PLATE.

FIG. I.—Part of a Transverse Section of the Leaf of *Pinus Sylvestris* taken through the Region of a Stoma. $\times 500$ diameters. *c.* Cuticle, *e.* Epidermis, *h.* Hypodermis, *g.* Guard cells of the stoma, *o.* Orifice of the stoma, *l.* Lacune of the stoma, *p.* Parenchyma containing chlorophyll.

FIG. II.—Part of a Transverse Section of the Leaf of *Pinus Sylvestris*, taken through the Region of a Resinous Passage. The cells of the hypodermis are shown surrounding a layer of resin cells which enclose the intercellular resin-passage.

DESCRIPTION.

ON THE MINUTE STRUCTURE OF THE LEAF.

1°. *The General Arrangement of Parts.*—A magnifying power of about fifty diameters is sufficient to bring the entire transverse section within the field of the microscope, and yet quite adequate to display the systems of tissue which combine to form the whole structure. Under these circumstances the following details may be readily identified :—The *epidermal boundary*, every here and there interrupted by a stoma, overlies a second layer, one cell deep, which, at variable intervals, is connected with rings of cells; they usually form a single layer, and surround the cells of the resin passages indicated in Fig. II; this layer is the *hypodermis* (Fig. I. *h.*). Underneath the hypodermal layer comes a zone of large peculiarly shaped parenchymatous cells containing chlorophyll, and this is limited internally by a sheath-like ring of single ovoid cells which encloses the axial portion of the structure; this last named part, is occupied by large thin-walled cells which envelop two sub-centrally placed fibro-vascular bundles

2°. *The Special Characters of the Separate Systems.*—(i) *The Epidermal System.*—The peculiarities of the cellular elements which build up the leaf structure may be made out with magnifying powers of from three to five hundred diameters. The epidermis is composed of a single layer of cells the external boundaries of which coalesce to produce a cuticle, the structural details of which are essentially similar to that of the holly, which has already been described.¹ The lower portions of the epidermal cells become enormously thickened, and exhibit a lamellar stratification, so that the central cell space becomes almost occluded. The intercellular partitions obtain as distinct homogeneous septa between the cells themselves, but become lost as they approach the external boundary of the cuticle.

¹ *Ut supra*, pp. 277—278.

At irregular intervals the epidermis dips down to form a stoma ; this is well shown in Fig. I, where it may be seen that an external vestibule is formed by the inward elongation of two epidermal cells, the cuticular borders of which tail off towards the orifice of the stoma. The orifice is bounded by two sub-triangular epidermal cells, over which the cuticle becomes attenuated, and is finally lost on reaching the lacune of the stoma over which these two so-called *guard cells* project. The stoma thus places the chlorophyll bearing tissue in direct communication with the external atmosphere.

(ii.) *The Hypodermal System* forms a continuous layer of single cells immediately below the epidermis. The cells are thickened after the fashion of the lower part of the epidermal cells, and, like those elements, exhibit intercellular septa ; they moreover often intercommunicate by means of pore canals, and these sometimes produce the bordered pits so characteristic of the *Coniferae*. In the region of the resin passages, the hypodermal-like outgrowths envelop those passages. In the region of the stomata the layer of cells becomes discontinuous and terminates next to the guard cell, on each side of the orifice of the stoma.

The resin passages consist of intercellular spaces surrounded by a single layer of thin-walled resin cells, which are filled with a finely granular protoplasm. Their cell walls do not exhibit intermediate partitions.

(iii.) *The Internal Parenchyma* consists of two distinct portions, an outer and an inner zone. The outer zone is composed of large cells with thin walls, the common cell walls of which are distinctly partitioned off from each other, and tend to form intercellular spaces at their angles. Incomplete folds of the cell walls project into the cell spaces and divide them into chambers. Their protoplasmic contents are coarsely granular lodge chlorophyll bodies, and eliminate globules of oil. The inner is separated from the outer zone by a sheath-like layer of thin-walled ovoid cells, which encloses a mass of large thin-walled spheroidal cells, and envelop the two sub-centrally lodged fibro-vascular bundles. All these cells are colourless, and contain an almost homogenous hyaline protoplasm.

(iv.) *The Fibro-Vascular Bundles*, are imbedded in the central parenchyma sometimes close to one another, but oftener widely separated. In the latter instance they are surrounded by an outer and intermediate zone of much thickened cells which resemble those of the closed bundles of most monocotyledons ; this evidently represents the hard bast. On one side of the bundle a layer of large extremely thin-walled cells passes gradually into thicker walled elements, which, from their linear arrangement, seem to be produced from the cambiform layer (which occupies at least one-half of the compact portion of the bundle), and to pass outwards to form the large thin-walled cells which constitute the soft bast. The cambium layer is largely developed, and is bounded on the other, external, side of the bundle, by the thick-walled hard-bast sheath already alluded to ; its cells retain their characteristic parallelopipedal forms even after the tissue has ceased its active growth, and become closed. In some cases a few xylem cells may be detected between the cambium and the boundary ring of bast fibres.

The methods of cutting the sections and staining them with logwood have already been fully detailed at pp. 15—16, 85.



A. J. S. 1891.

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V. S. STOMACH OF DOG.
Pyloric End
X 65

THE ALIMENTARY CANAL.¹

THE STOMACH.

Etymology.—STOMACH (stŭm'ak), *n.* [Lat. *stomachus*, Gr. *στόμαχος*, from *στόμα*, a mouth, any outlet or entrance; Fr. and Pr. *estomac*, Sp. and Pg. *estomago*, It. *stomaco*].

Anatomy.—The stomach is that portion of the alimentary canal which commences at the termination of the œsophagus, and places that structure in direct continuity with the duodenal part of the small intestine. Its œsophageal extremity is termed the *cardiac*, and its duodenal, the *pyloric* end.

EXPLANATION OF PLATES.

THE STOMACH.

FIG. I.—*Cardiac Gland of Bat*, $\times 420$, (LANGLEY). *d.*, columnar epithelium of the surface; *c.*, central cells; *p.*, parietal cells. The upper part of this simple form of gland contains both central and parietal cells and is termed the neck; the lower portion, or fundus, is occupied by only central cells, which exhibit peripheral granules towards the lumen of the gland.

FIG. II.—*Cardiac Gland of Dog*, $\times 350$, (KLEIN). *d.*, duct or mouth of the gland; *n.*, neck of the gland.

FIG. III.—*Cardiac Gland of Dog*, $\times 450$, (KLEIN). Portion of the fundus of the gland; *c.*, central cell; *p.*, parietal cell.

V. S. STOMACH OF DOG.

Pyloric End $\times 65$.

The muscular tunics are not shown; *e.*, columnar epithelium covering the folds of the mucosa; *d.*, neck of the gland tubule; *m'*, mucosa of the region of the necks of the tubuli; *m.*, mucosa of the region of the body of the gland tubuli, showing the latter cut in different directions; *m m.*, muscularis mucosæ; *f.*, lymphoid follicle; *a.*, blood-vessel in submucous region; *s.*, submucosa.

DESCRIPTION.

The mucous membrane of the stomach, like that of the œsophagus, consists of an epithelial layer which becomes continuous with the cells of the gland tubuli; these lie in the mucosa which also supports the external epithelium. Beneath the mucosa comes the muscularis mucosæ, and this overlies the layer of submucous tissue. All these together constitute the mucous membrane, and this is fixed to a thick muscular tunic of non-

¹Continued from p. 284.

striped elements, which consists of an inner comparatively thick circular coat, and an outer thinner longitudinal layer. Oblique fasciculi also obtain on the inner side of the circular coat (GILLENSKOELD). The sub-mucous connective tissue passes insensibly between the bundles of the external muscular coats to form their perimysial zones, and these, in the same way, coalesce to form the outer limitary boundary of connective tissue, known as the deeper layers of the serous coat,—the peritoneum.

The epithelium of the free surface of the gastric mucous membrane consists of a single layer of columnar cells of much elongated narrow forms. Each cell is provided with a basal oval nucleus imbedded in a densely reticulated protoplasm, the meshes of which become looser towards the upper part of the cell; the peripheric border of the cell is not provided with a striated rim. At intervals some of the cells become changed into mucus-secreting chalice cells, and this is chiefly observable during active digestion when all the cells are secreting mucus (KLEIN¹). According to WATNEY², proliferation of the columnar epithelium both of the free surface and of the ducts, takes place between the smaller fixed ends of the cells, and is manifested in the form of round or oval buds of varying sizes and numbers; and sometimes in small groups. The connective tissue corpuscles beneath the epithelium moreover send out processes which become lost in the cement substance which binds the columnar cells together. WATNEY has also shown that the epithelium is supported by a basement membrane composed of these branched and nucleated endothelial plates.

At the juncture of the œsophagus with the stomach the stratified epithelium of the former ceases abruptly; its lowermost layer of columniform cells alone persists, and eventually forms the gastric epithelium. In its passage into the small intestine, the columnar single layer passes gradually into the somewhat similarly constituted epithelium of that organ.

The mucosa may be resolved into a structure poor in connective tissue fibres, but rich in endotheloid cells; it also possesses a few lymph corpuscles, and in all parts of the stomach, except the transitional areas between that viscus and the œsophagus on the one, and the small intestine on the other hand, is the region in which lie lodged its special glandular structures. In the cardiac end and fundus of the stomach the gland tubes are more or less vertically placed and closely apposed to one another in groups of from four, five, and more. The connective tissue separating these groups varies in amount at different depths; it is much greater towards the surface than at the deeper portion of the ducts. In the pyloric end of the stomach, a gradual transition leads to the formation of somewhat narrow foldlike processes of the mucosa between the ducts of the glands, and endows that region with a villous-like aspect; this becomes the dominant feature of the extreme pyloric end, until, by further differentiation, the true villi of the duodenum are produced. In the deeper part of the pylorus the glands branch, and the mucosa entirely surrounds and lodges them; this restriction of the glands to the mucosa

¹*Atlas of Histology*, London, 1880, p. 203.

²*On the Minute Anatomy of the Alimentary Canal*, *Phil. Trans. Roy. Soc.*, London, 1876, p. 451—488.

proper, however, is broken into in the zone which lies between the pylorus and the duodenum, and, in the *Carnivora* especially, it may be observed that the pyloric glands pass through a portion of the structure, at which the underlying muscularis mucosæ becomes discontinuous, to penetrate the submucosal region, and to merge into the glands of *Brunner*, which are confined to the first portion of the duodenum.¹

The termination of the gland tubes is supported below by an appreciable zone of connective tissue rich in corpuscles; this layer forms the base of the mucosa, and is more distinctly marked in both the small and large intestines than in the stomach.

The muscularis mucosæ forms the boundary of division between the mucosa and the submucosa; it consists of a band of non-striped muscle cells, which varies in thickness at different parts; it is thickest at the summits of the folds of the mucous membrane; this is especially well shown in the neighbourhood of lymphoid follicles in the intestinal tract, and will be alluded to again. The muscularis mucosæ is usually divided into an inner circular and an outer longitudinal layer; occasionally a third inner oblique or longitudinal layer obtains. WATNEY² has pointed out that many fasciculi penetrate into the mucosa and pass into the tissue between the gland tubuli; some of these become attached to the basement membrane of the epithelium, others maintain a horizontal course. In the stomach of the cat, ZEISSL has shown that a moderately thick zone of elastic fibres forms a membrane on the outer side of the mucosa, and is penetrated from beneath by muscle fibres, blood-vessels, etc.

The submucous tissue, like that of the œsophagus, consists of a loosely arranged fibrous meshwork with its corresponding corpuscles. It lodges the twigs of the blood-vessels, lymphatics, and nerves which supply the mucous membrane generally.

The glands which are concerned with the secretion of the gastric juice have already been localised. They are distinguished into two varieties which, in their typical forms, differ from one another both morphologically and physiologically; nevertheless they pass by gradual transitions into each other. It is only recently that an attempt has been made to assign to these glands, names which, at least, are free from objection. To J. N. LANGLEY³ belongs the honour of introducing a rational nomenclature; he says:—

“I propose to use the term *oxyntic* glands, (*ὀξύενειν*, to make sour, to acidulate), for those glands in the stomach which are differently called by different observers ‘fundus,’ ‘peptic,’ or ‘rennet’ glands. It is only after great hesitation that I venture to employ a new term, but without a new term I find myself reduced to circumlocution or inaccuracy. That the present nomenclature is unsatisfactory scarcely needs to be pointed out. In the rat there are no glands in the fundus of the stomach; in the rabbit the glands of the fundus proper differ in some important points from those of the greater curvature, yet both are called fundus glands. The terms peptic and rennet glands are inappropriate, since the pyloric glands also secrete the peptic and rennet ferments. The terms ‘simple’ and ‘compound’ glands suggested by EBSTEIN⁴ are applicable only to the gastric glands of mammals,

¹This is well figured by NOBLE SMITH, in KLEIN'S *Atlas of Histology*, London, 1880, Plate xxxiv, Fig. iii.

²*Loco citato*.

³*Philosophical Transactions of the Royal Society*, London, 1881, pp. 665-666.

⁴*Max Schultze's Archiv*, 1870, Bd. vi, s. 538.

for it is only in mammals that compound glands, i. e., glands possessing both border and chief cells occur."

"The one characteristic point of the 'fundus' 'peptic' or 'rennet' glands in all animals, is the secretion of an acid fluid. The characteristic is suggested by the word *oxyntic*."

The Oxyntic Glands.—Each oxyntic gland admits of a rough division into three parts,—the *duct*, the *tube* or *neck*, and the *body* or *fundus*. They were first recognised by HEIDENHAIN¹, but afterwards more fully described by PARTSCH².

One duct generally serves for the outlet of two or three tubes. The cells of the duct resemble, in all essential details, those of the free surface of the mucous membrane; they surround a comparatively large lumen in most mammals. The lumen of the neck is extremely narrow and can thus be readily distinguished, even in transverse sections, from that of the short duct: it is directly continuous with the lumen of the fundus which at its lower extremity becomes somewhat wider.

The cells which enter into the formation of the oxyntic glands are of two kinds; both of these lie within the basement membrane which bounds the tubuli. The whole of the neck and fundus is lined by a single row of columnar cells, which are directly continuous with the cells of the duct, but they differ from the latter in size; they are smaller, denser, somewhat cubical, and possessed of small oval nuclei in the neck; as these pass into the cells of the fundus, they assume a more distinctly columniform shape, and are longer and more transparent than their representatives in the neck. HEIDENHAIN³ termed them the *chief* cells, ROLLETT⁴ called them *adelomorphous*; they have also been termed *central* cells, since they surround the lumen of the tubuli. According to KLEIN⁵, the granular aspect of these cells and their nuclei, is due to a reticulum within them, the meshes of which contain a hyaline interstitial substance of variable quantity; the more granular the cell, the closer is this reticulum.

But besides these cells there are others, which, under the name of *peptic* cells, were long considered to be the only cells of the gastric tubuli. They were first shown by HEIDENHAIN³ to lie between the chief cells and the basement membrane; he, therefore, termed them *parietal* cells—the *adelomorphous* cells of ROLLETT, *oxyntic* cells of LANGLEY, and *border* cells of other writers. These cells are somewhat oval or spherical in outlines, and slightly compressed vertically; they are much more easily detected than the chief cells, on account of their opaque, granular substance, and its ready imbibition of staining reagents; each cell possesses a clear, oval nucleus, and, in consequence of its shape and position, often causes the membrana propria to bulge out, and thus gives rise to the sinuous outline of the gland tubes in the dog and most other mammals; in the porpoise and the pig the cells are situated in special recesses formed by the protrusion of the basement membrane, and communicate with the rest of the tubule by means of

¹Max Schultze's *Archiv*, 1870, Bd. vi, s. 394.

²Max Schultze's *Archiv*, 1877, Bd. xiv, s. 179.

³*Loco citato*.

⁴Graz *Unters*, 1871.

⁵*Atlas of Histology*, 1880, p. 204.

narrow orifices. In the proventriculus of birds, this is carried to a greater extent, and the parietal cells occur in secondary tubules; these lead into the principal tubule, which contains only chief cells. In frogs, only parietal cells are found in the oxyntic glands, but this is compensated for by the occurrence of glands with chief cells in the œsophagus. KLEIN has shown that the densely granular aspect of these cells is due to intracellular and intranuclear networks.

In location, the parietal cells are of commoner occurrence towards the neck of the tubule; they are more sparingly developed in the fundus, and cease altogether at the duct. Indeed, this is so constant amongst the higher *Mammalia*, that KLEIN has stated that it is possible to recognize whether the tubule is cut transversely at the neck or fundus, when taken together with the evidence furnished by the size of the lumen and the quantity of intertubular connective tissue.

The gland tubes are arranged somewhat vertically side by side, they may be straight or wavy, and their ends are usually curved to one side like a hook; but it depends very largely upon the animal what these proportions and shapes shall be, for they are determined by the form and position of the cellular elements which build up the gland tubuli, as has already been shown.

As the pyloric end of the stomach is approached, the glands gradually become altered in characters until they merge into the form typically known as the *pyloric gland*.

The Pyloric Glands.—As in the oxyntic glands, these structures admit of a three-fold separation into *duct*, *neck*, and *fundus* portions. The duct is relatively long, it usually amounts to about half the length of the entire tube, its epithelium is similar to that of the free surface of the stomach. Into the duct, from two to three tubes open by very short necks, each with a minute lumen; they widen out to form the fundus which is generally divided into two or three wavy branches. The epithelial lining of the neck and body is a continuation of that of the duct; its cells, however, are shorter and denser, those of the neck being almost cubical, whilst the fundus cells are more transparent and of columnar form. In minute structure they resemble the chief cells of the oxyntic glands, *i.e.*, they are composed of a delicate reticular substance.

The basement membrane of all the gastric glands is composed of a network of endotheloid cells with branched processes; some of these are fused with the subjacent mucosa, whilst others extend into the epithelium, there to become absorbed in the interstitial cement substance of its cells.

During active secretion the chief cells of the oxyntic glands show a separation of granular elements towards their peripheral portions next to the lumen; it has been shown by LANGLEY¹ that some of these granules become discharged with the secretion, and that after digestion they gradually retire, so as to cause the cells to reassume their uniform granular aspect, which they exhibit during rest. This is well seen in the illustration of the cardiac (oxyntic) gland of the bat. According to HEIDENHAIN¹ both the chief and the parietal cells become bulkier during digestion, and on the cessation of active secretion may shrink to even

¹*Loco citato.*

less than their original sizes ; these changes are said to occur later in the parietal than in the chief cells. In the pyloric glands, the changes which occur in the cells during the active and passive states of the organ, are strictly comparable to those which take place in the chief cells of the oxyntic glands.

The mucosa of the stomach, more particularly at its pyloric end, is often invaded by lymphoid follicles ; these are met with more frequently in the organs of young subjects ; they are confined to the mucosa and fade off gradually into its tissues.

THE BLOOD-VASCULAR SYSTEM resembles that of the œsophagus, except in the mucosal region. The capillary network of the mucosa is prolonged into an elongated meshwork of capillaries which envelop the tubuli, and give rise to a dense horizontal plexus immediately beneath the epithelium ; from this the venous rootlets arise.

THE LYMPHATIC SYSTEM.—The researches of LOVÉN¹ have shown that a dense canalicular system surrounds the tubuli and blood-vessels of the mucosa around the bodies of the gland tubes ; from this, numerous lymphatics proceed to a deep plexus of larger vessels in the submucosa (TEICHMANN²). Other lymphatics, which take a longitudinal course between the gland tubes, open into the plexus around the bodies of those structures, and after freely anastomosing, extend towards the surface, where they terminate in loops or saccular diverticula. Very often the lymphatics invaginate portions of the gland tubes.

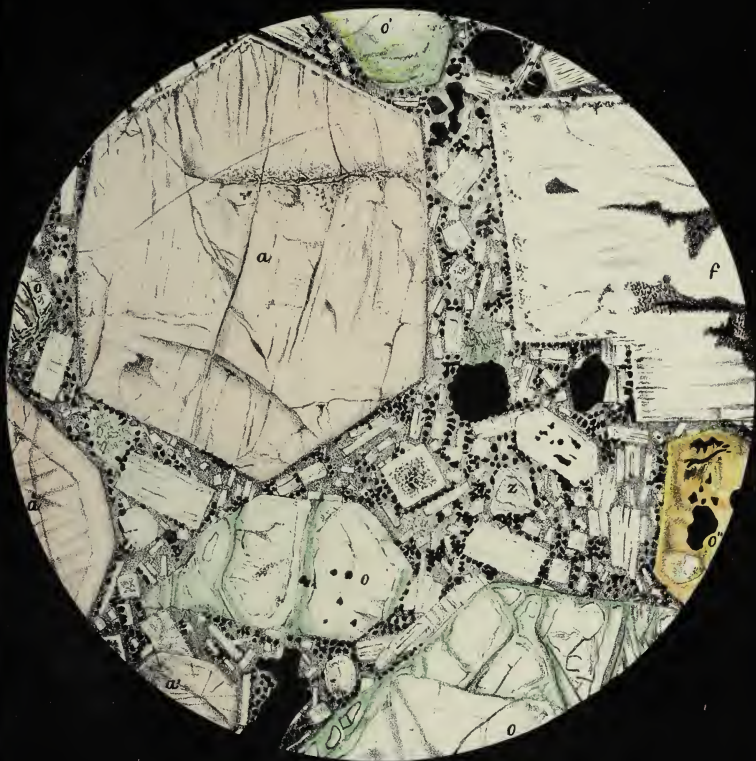
METHODS OF PREPARATION.

THE NERVOUS SYSTEM.—The nerves, which are large, are derived from both branches of the pneumo-gastric, the right branch descends upon the back and the left branch on the front of the stomach. Branches from the sympathetic system also proceed to the stomach from the solar plexus. The nerve trunks of both systems carry minute ganglia (REMAK). The branches enter the muscular coat and extend between its layers, as the plexus of AUERBACH, which contains many ganglion cells from apolar to multipolar forms. From this stratum proceed branches into the submucosa, where they form the plexus of MEISSNER, which includes minute unipolar and bipolar ganglion cells. According to RABE, a rich plexus of nerves surrounds the gastric glands of the horse, and some of them end in peculiar doubly nucleated spindle cells.

The methods of hardening, and of cutting, and staining sections of the stomach have been fully detailed with regard to other parts of the alimentary canal. (pp. 264—284).

¹*Nord. Med. Ark.* Bd. v, 1873.

²*Das Saugadersystem*, 1861.



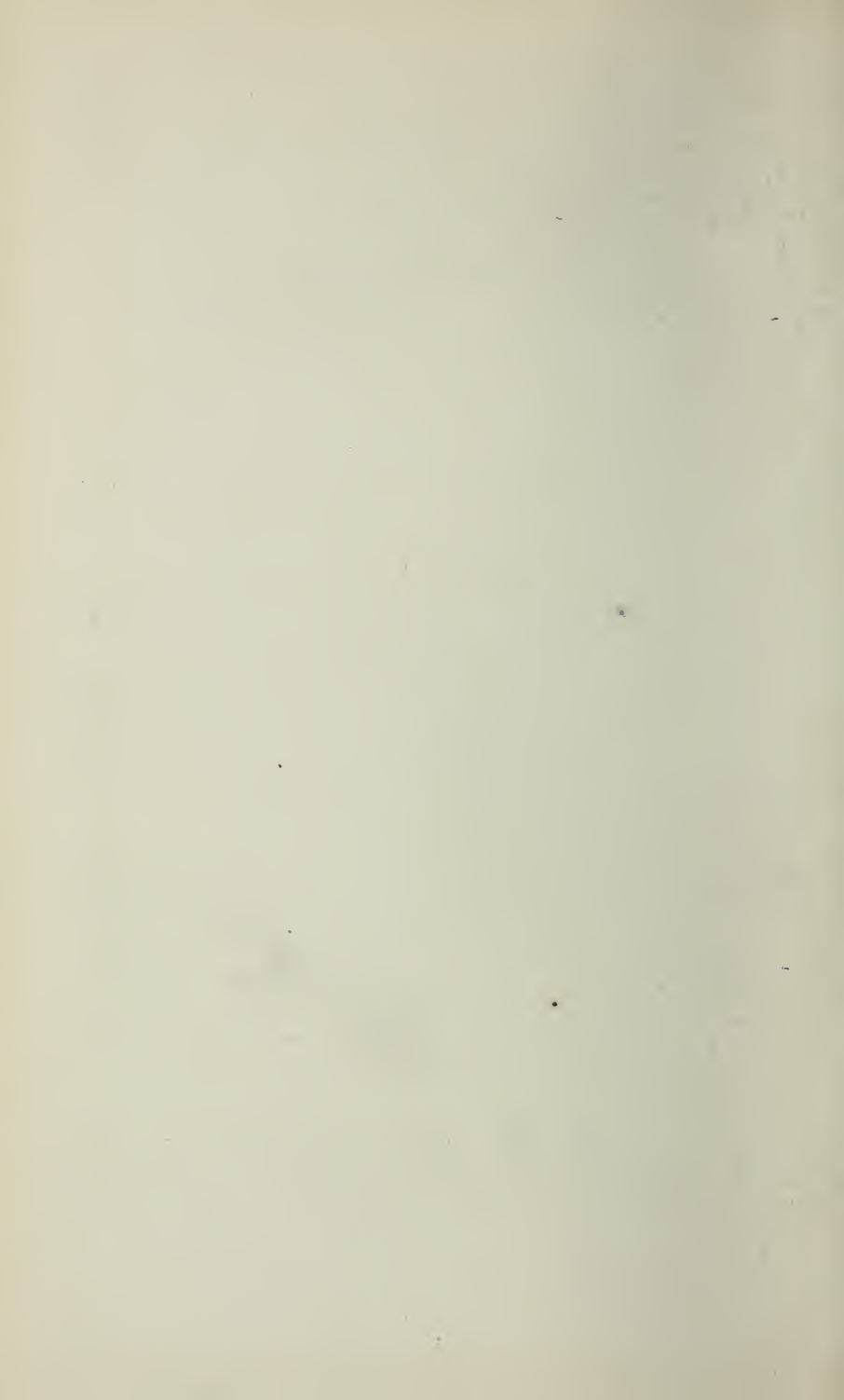
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West, Newman & Co. lith.

PORPHYRITIC BASALT

The Lion's Haunch, Arthur's Seat,
Edinburgh.

X 25



PORPHYRITIC BASALT.

The Lion's Haunch, Arthur's Seat, Edinburgh.

Etymology.—ΠΟΡΨΗ-ΡΙΤΙΚ, *a.* [Pertaining to, or resembling PORPHYRY. Fr. *porphyre*, Pr. *porfiri*, Sp., Pg., and It. *porfido*, Lat. *porphyrites*, from Gr. πορφύρεος, like purple, from πορφύρα, purple].

Petrology.—A rock composed of a compact, usually felspathic base, through which larger crystals of felspar are scattered. The base may be of a purple, red, green or other colour. The crystals are of a lighter tint than the base, and may be white or colourless. "The term, however, is sometimes applied to some of the acidic felspar rocks, where the *porphyritic* texture is very characteristic. Thus we have *felspar porphyry*, *quartz porphyry*, *hornblende porphyry*, etc." (A. GEIKIE¹).

BA-SALT (ba-sawlt'), *n.* [Fr. *basalte*, Lat. *basaltis*, a dark and very hard species of marble in Ethiopia, an African wood². (*Petrology*).—"Under this title I include all those rocks of the augite-felspar series which have a compact or finely granular base, through which the component crystals of triclinic felspar (probably always labradorite) augite, olivine, and magnetite are crowded. This base consists partly of minutely granulated augite, and microlites probably of the felspar. It varies much in amount, sometimes almost disappearing; at other times occupying by far the largest bulk of the rock, and with only a few scattered crystals of the usual minerals, as in some of the most compact homogeneous basalts." (A. GEIKIE³).

EXPLANATION OF PLATE.

Porphyritic Basalt, The Lion's Haunch, Arthur's Seat, Edinburgh
× 25 diameters.

a. Large well defined crystal of augite; *a'*. Crystal of augite showing zonal structure; *a''*. Small crystal of augite, around which slender prisms

¹*Descriptive Catalogue of Rock Specimens, Edinburgh Museum of Science and Art, Edinburgh, 1870, p. 92.*

²PLINY, *Nat. Hist.*, 36, 7. Cf. STRABO, 17, p. 818.

³*On the Carboniferous Volcanic Rocks of the Basin of the Firth of Forth, Trans. Roy. Soc., Edinburgh, 1879, Vol. xxix, p 499.*

of felspar are arranged in beautiful fluxional structure; *o*. Olivine, showing fissures of metamorphism serpentinised. *o'*. Olivine, pseudomorph of tufted and streaky greenish serpentine; *o''*. Olivine, pseudomorph of limonite; *f*. One third of a large crystal of labradorite in which two large cavities are shown filled with a brownish glassy substance; in one of the cavities the glass is devitrified by a trellis-work of obliquely intersecting rods of one of the oxides of iron; above this felspar is a six-sided opaque black crystal of titaniferous iron. Towards the centre of the picture, between *a* and *f*, is an aggregate of small octahedra of Magnetite. The opaque black smaller crystals in the vicinity of the hexagon of titaniferous iron are probably iserine. At the bottom of the plate, between *o* and *a''*, a broken plate of titaniferous iron is represented; *z*, a small space filled with a fibrous zeolite. The magma consists of a small quantity of colourless interstitial glass which binds together numerous granules of pinkish-brown augite, small crystals of plagioclase exhibiting fluidal structure, and many acicular and minute pellucid forms, some of which are felspar, whilst others are probably apatite; almost the whole of this area is thickly studded with small octahedra of Magnetite. Occasional greenish patches (viridite), and brown spots (ferrite), fill up gaps in the magma; they are usually devoid of Magnetite, but are almost invariably crowded with translucent crystallites.

DESCRIPTION.

Arthur's seat, the name of a hill situated on the eastern boundary of the town of Edinburgh, forms an eminence at its eastern division, which is supposed to resemble the outlines of a recumbent lion. The lion's haunch consists of a rudely columnar bed of basalt,—the remains of a neck which seems to have proceeded as a southerly offshoot from the main plug, which now forms the summit of the hill. According to GEIKIE¹ it is of Permian age.

The denuded surface of the rock is very much exposed to atmospheric agencies, and, as a consequence, it is difficult to procure perfectly fresh samples; these can be obtained, however, by breaking through some of the larger detached fragments which strew the southern base of the mass. It will be found that the weathering of the rock extends as a thin outer crust over the superficies of its mass; but that, because of its porphyritic nature, it also extends for some distance within the rock texture. On account of the columnar structure of the bed, large fragments are detached, and the destructive work is facilitated by its open situation.

¹*Descriptive Catalogue, etc.*, Edinburgh, 1870, p. 19, *et seq.* For descriptions of the geology of Arthur's Seat, see also :—MACLAREN, *Geology of Fife and the Lothians*; A. GEIKIE, *Geol. Survey Memoir*, and *Map 32 of Scotland*; JUPP, *Quart. Journ. Geol. Soc.*, Vol. xxxi, p. 131.

In texture, the rock, when quite fresh, is of a black colour and very compact; with the aid of a lens its porphyritic nature may be detected in the numerous large glassy crystals of labradorite, occasional dark glancing forms of augite, and patches of honey-yellow and greenish olivine, which everywhere stud the otherwise finely-grained black ground mass. In moderately thin sections the labradorite retains its glassy aspect; the augite assumes a pale claret to warm brown tint, and the olivine is seen either in whitish masses traversed by strings of yellowish green, or in crystals of subopaque green and yellow colours.

The characters of the larger porphyritic crystals may be readily determined with a low power of the microscope (25 diameters), but for the resolution of the dark matrix, and the recognition of the minute forms which occur within the larger crystals, a moderately high power (from 300 to 500 diameters) is necessary.

In the descriptions of dolerite and diabase¹, I drew attention to the nomenclature of the group of rocks to which basalt belongs, and pointed out, that a rational classification depends, not so much on the mineralogical or chemical constitution of the mass, as on the physical conditions under which it took permanent form. In extension of those observations, I shall now show, that the rock of the Lion's Haunch, is a typical example of basalt, *i.e.*, a volcanic rock which became solid at or near the surface of the earth, under conditions of *gradual* loss of temperature; and that, when the molten mass acquires solidity rapidly, as in fusion experiments, the rock becomes first tachylitic, and may ultimately assume the aspect of a pitchstone or obsidian.

Thus it appears, from a study of natural phenomena combined with the analytic and synthetic results of the laboratory, that from one source spring four chief phases, which pass by gradations into one another, and give us the types *diabase*, *dolerite*, *basalt*, and *tachylite*. The first of these types passes insensibly into *diorite* and is thus linked with the more obscure group which has its centre in *granite*. Metamorphic and degenerative processes transform them, and thus result *Ilherzolite*, *pikrite*, *serpentine*, *palagonite-rock*, *kaolin*, etc.

Before I pass on to the special consideration of the mineral components of the basalt of the Lion's Haunch, I shall record the results of a few preliminary experiments on the fusion and re-solidification of the molten mass under varying conditions².

¹*Ut supra*, pp. 190—196, et 221—226.

²For these experiments I am indebted to the kindness of Mr. W. HAMPTON, F.C.S., of Hanley.

No. of Crucible.	State of Contents.	Remarks.
No. 1.	Nearly fused.	Cooled slowly. Pyrometer registered 24°.
No. 2.	Nearly fused.	Cooled slowly. Pyrometer registered 29°.
No. 3.	Completely fused.	Cooled very rapidly. Pyrometer registered 70°. White heat.
No. 4.	Completely fused.	Cooled comparatively slowly. Pyrometer bit larger when fired than when in clay state. Blinding white heat.

In No. 1, the ground mass has become so far amalgamated that all trace of a minutely crystalline texture had disappeared with the exception of a few of the felspar prisms. Of the porphyritic crystals the felspar remains intact; the augite but slightly altered at the edges and in colour; the olivine shows signs of breaking down, and the iron is no longer recognisable as such. The whole mass has become very vesicular.

No. 2, presents all the peculiarities of No. 1; in addition, its ground mass is somewhat more fused and exhibits occasional patches of a brownish-yellow glass. The augite, and the olivine, are somewhat more changed than in No. 1. The felspar remains practically unaltered.

No. 3. The whole of the mineral constituents have been fused, and the result is a rich-brown glass, the cracks of which are traversed by black films which every here and there become tufted; at occasional spots rounded glassy centres may be seen, from which numerous highly refractive needles radiate. The white spots represent former felspar.

No. 4 has resulted in a complete fusion of all the minerals, with the exception of nuclei of felspar, which are usually rounded, and have their boundaries invaded by the glassy spicules as in No. 3. In some cases the nuclei show the original form of the felspar. These felspathic nuclei with their radiating glassy needles, which seem to be derived from them, form centres around which the rich-brown glass collects in mammillary aggregations; and the whole structure is built up of similar systems. Where the mammillæ of separate systems meet, an intervening space results, and becomes filled with a homogeneous honey-yellow glass. Under fully crossed Nicols the edges of the mammillæ exhibit a delicate radial striation; the glassy spicules remain brightly luminous. On revolving the polariser both the nuclei and their spicules give the reaction of plagioclase. Spherulitic structure, such as that just described, is by no means unknown amongst vitreous rocks, and this experi-

ment is of special interest, as it shows that the passage from basalt to tachylite is entirely dependent upon the external circumstances under which the molten mass became solid.

THE SPECIAL CHARACTERS OF THE MINERAL CONSTITUENTS. — THE FELSPAR. — There can be no doubt that the colourless felspar first took form in the process of consolidation. Evidence of this is to be found in the retention of its crystalline shape even when subjected to enormous temperatures, and from the fact that the crystals contain numerous cavities which are filled with an amorphous brown to yellowish brown glassy material devitrified by minute rods and dendrites of iron. Large felspar crystals are numerous, and give the rock its characteristic porphyritic aspect, but the whole field is crowded with smaller prisms of the mineral which were probably formed later in the solidification of the structure, for some of them exhibit beautiful fluidal structure, both around the larger members of their own species and the large crystals of augite. Air and fluid cavities, minute rounded grains of augite and of iron, and glassy spicules which may be either felspar or apatite, occur more or less abundantly throughout all the crystals. The felspar is labradorite.

THE AUGITE, next in quantity to the felspar, occurs in two forms; first, as large porphyritic crystals, which must have been formed very shortly after the large labradorite, for they are sometimes intercrystallised with the latter; and secondly, as small rounded and elongated grains, closely aggregated, so as to give rise to a large portion of the so-called matrix or base of the rock. The larger crystals are of a pinkish-brown colour, and very often of extremely regular shapes; they seldom contain inclusions, although some of them appear to be built up of congeries of granules, and envelop occasional iron particles. More rarely crystals of olivine are imbedded within the augite; zonal growth may also often be detected, and in some cases a mélange of the magma becomes wrapped up in the central portion of the crystal. The smaller granules are invariably rounded and do not present sharp angles; they vary from a faint yellowish to a brownish-pink tint.

THE IRON consists chiefly of Magnetite in grains and small octahedra scattered thickly throughout the magma. It sometimes happens that patches of iron crystals with rudely definite forms may be detected with a low power; on the application of a higher power these may be resolved into closely aggregated minute octahedra of Magnetite. It also obtains in the form of lamellæ and hexagons of titaniferous iron, and probably also as iserine. Within some of the large felspar crystals, it may sometimes be seen as an assemblage of minute trichites disposed trellis-wise, but more commonly as a feltwork of very small trichites in a brownish glass.

THE OLIVINE is well defined in large and small crystals throughout the field. In some instances its borders have become converted into serpentine, and it is traversed by serpentinised fissures of metamorphism,

In other cases the entire substance of the mineral has given place to a tufted and streaky greenish serpentine ; whilst occasionally, nothing but a pseudomorph of limonite remains to point out its former existence. Particles of Magnetite very frequently lie imbedded within the olivine, sometimes to such an extent as to give it a closely spotted appearance.

Under a high power of the microscope the individual grains of augite, Magnetite, and minute felspar crystals are seen to be bound together by a clear homogeneous glassy substance, and it is, moreover, abundantly traversed by minute glassy spicules, which may be apatite, but more probably are felspar. Every here and there the ground mass merges into a clear greenish patch of irregular form, which is crowded with transparent microliths, but is devoid of grains of augite and Magnetite. Similar brownish patches, too, are not uncommon.

Spaces in the structure are usually filled with some fibrous zeolite ; of these radiated balls may rarely be seen and are probably Prehnite. Laminated tufts also occur in the neighbourhood of the last named mineral, and may be pectolite.

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T.S. DUODENUM OF DOG.
 X 25.

THE ALIMENTARY CANAL¹.

THE SMALL INTESTINE.

Etymology.—IN-TĒS'TĪNE, *n.*; *pl.* IN-TĒS'TĪNES, [Lat. *intestinus*, from *intus*, on the inside, within; It. and Sp. *intestinalo*, Fr. *intestin*].

Anatomy.—That portion of the alimentary tract which extends from the distal (pyloric) end of the stomach to terminate in an external orifice, —the *anus*. It is divided, in the higher animals, into two chief portions which differ from each other both in structure and functions, and are known as the *small* and the *large* intestines. The small intestine is further subdivided into three sections which pass by gradations into one another, and are termed respectively, the *duodenum*,² *jejunum*³ and *ileum*⁴ The ileum opens by a valvate aperture (the *ileo-cæcal*, or *ileo-colic* valve.) into the first portion (*cæcum* or *colon*) of the large intestine.

EXPLANATION OF PLATE.

T. S. DUODENUM OF DOG.

× 25 diameters.

v., villus; *c.*, crypt of LIEBERKÜHN; *mm.*, muscularis mucosæ; *s.*, submucosa containing the gland of BRUNNER; *d.*, duct of one of the glands; *s'*, lower submucosa devoid of glands, and of very loose texture; *m'*, circular muscular coat., *m''*, longitudinal muscular coat; *a.*, plexus myentericus of AUERBACH.

DESCRIPTION.

The structures which enter into the formation of the small intestine, may be considered under the following heads:—the *mucous membrane*, the *muscular coat*, and the *serous coat*, and these are richly supplied with vessels and nerves. The mucous membrane of the small intestine is raised up into numerous permanent folds which extend inwards in a direction at right angles to the length of the tube, and thus form a series of dissepiments of variable size, in addition to the effaceable rugæ which beset its walls. These are the valves of KERKING known as *valvula conniventes*; they serve to increase the surface of the mucous membrane,

¹Continued from p. 292.

²N. Lat., from *duodeni*, twelve each; so termed because its length is about twelve fingers' breadth.

³Lat. *jejunus*, empty, dry; originally so named because it was supposed to be always empty after death.

⁴N. Lat. *iliacus*, from *ilia*, groin, flank, small intestines, N. Lat. *ileum*,, *ileon*, the last portion of the small intestines, from Gr. *εἰλεῖν*, *εἰλεῖν*, to roll, to twist up.

an important factor in the function it performs as an absorbing and secreting organ. The valvulæ conniventes commence at a short distance from the pyloric end of the stomach, and attain their maximum development near the orifice of the bile and pancreatic ducts within the duodenum; they continue to be well marked until the lower half of the jejunum is reached, and thereafter diminish both in size and number towards the end of the ileum, where they cease altogether.

The mucous membrane, like that of the stomach, is made up of four distinct layers:—1°, the *epithelium*; 2°, the *mucosæ*; 3°, the *muscularis mucosæ*; 4°, the *submucosa*.

The *epithelium* may be taken as the outward expression of the glandular elements which are lodged within the other layers. Indeed the whole intestinal tract, may be looked upon as a huge tubular gland into which secondary minute tubules of various forms open and discharge their contents. In addition to the structures which endow the intestines with a secretory function, provision is made for its action as an absorbent organ, whereby formed material can find its way into the nutrient vascular systems of the body.

The chief characteristic of the small intestine lies in the peculiar disposition of its mucosa. It has already been stated that the valvulæ conniventes seem to be designed to produce a maximum secreting and absorbing surface, but this surface is immeasurably increased by the development of numerous minute elongated *villi* or processes of the mucosa; the external epithelium which stands vertically to the surface, is thus thrown into an infinitude of vallecule which have been described as glandular structures under the name of *crypts* of LIEBERKÜHN. True glands, *i.e.* those which each exhibit a neck, duct, and body, do find a place in the small intestine, but they are altogether subordinate and obtain only in its duodenal portion; they are known as the glands of BRUNNER, and from the fact that they pass by gradations into the pyloric glands of the stomach¹, and are similarly constructed though more deeply seated, it is possible that they exercise a secretory function analogous to that of the pyloric glands.

In form, the villi vary in different parts of the intestine, and in different animals; in the hedgehog they are lamelliform; in man, the dog, and cat, they are long slender and cylindrical; they are longer in the duodenum than in the jejunum and ileum; in the mouse they are short and conical.

The superficial epithelium consists of a single layer of beautiful columnar cells, each provided with an oval nucleus at its proximal fixed end. Both nucleus and cell substance consist of a reticulum of denser matter, the interstices of which are filled with a hyaline substance. The distal free border of each cell is provided with a striated rim, the markings of which are due to prolongations of the intracellular network. Every here and there the striated border is lost, and the body of the cell assumes a globular shape, from which the mucus now

¹*Ut supra*, p. 289.

escapes through the open free surface, and the nucleus retires to the other extremity, which becomes attenuated through the bulging out of the other part (KLEIN¹). It has been stated by THANHOFFER² that the fixed ends of the epithelial cells in *Rana* terminate in two processes, one of which is connected with a nerve, whilst the other passes to the tissue of the villus; but this certainly does not obtain amongst mammals; the ends of the cells are generally truncated, and at most exhibit only slight indentations (SCHÄFER³). The epithelial cells are held together by a clear homogeneous cement substance, which is in direct continuity with the adenoid reticulum of the mucosa below, and very often lymph corpuscles may be discovered between the columnar cells (WATNEY⁴). Where the upper portion of the mucosa is invaded by lymphoid follicles, the superjacent epithelium very often becomes altered in character; this is manifested chiefly in a loss of the columnar shape of the cells, and their subsequent degeneration into polyhedral forms, in which the nucleus becomes conspicuous.

The precise method by means of which nutrient matter finds its way into the central lacteals of the villi, is a matter which still remains undecided. One class of observers assert that the epithelial cells are themselves the active agents in this process, and that they absorb the formed material or chyle and then discharge it into the tissue of the villi, whence it is taken up by the central lacteals and thus conveyed to other parts of the bodily economy. This hypothesis is based on the assumption that there is a direct continuity between the cells of the epithelium and the tissue of the mucosa, an assertion which has been denied by most observers, and certainly does not hold good for the *Mammalia*. The other view, which is in accordance with observed facts, is that advocated by WATNEY, KLEIN, and others. The interstitial cement substance of the epithelium is in direct continuity with the mucosa; the presence of lymph corpuscles between the epithelial cells, would alone suffice to evidence this. In the fresh state the intercellular cement is easily permeable by fluids, and it may readily be imagined that the chyle thus finds its way into the mucosa. As the flow of formed material within the absorbent vessels is centripetal, the chyle would tend to pass towards the canalicular system and be taken up by it through its delicate walls.

The epithelium rests upon a *basement membrane*, which consists of a single layer of endothelial plates, provided with processes which extend in all directions (DEBOVE⁵).

In intimate structure the *mucosa* is essentially similar to that of the other parts of the alimentary canal. It is reduced to a comparatively narrow zone, from which elongated processes the villi extend vertically outwards. The free surface of these villi is covered with a basement membrane, which in its turn is surmounted by the epithelial layer. The spaces between the villi thus appear like glands, and were first described as such by LIEBERKÜHN⁶.

¹*Atlas of Histology*, London, 1880, p. 13.

²*Pflüger's Archiv*, 1873, Bd. viii.

³*Quain's Elements of Anatomy*, London, 1882, vol. ii, p. 603.

⁴*Phil. Trans. Roy. Soc.*, London, 1876.

⁵*Comptes Rendus*, Paris, 1872.

⁶*De Fabrica et Actione Villorum*, Amstel, 1745.

SERPENTINE.

Etymology.—SER'PEN-TINE, *n.* [Lat. *a. serpentinus*, Fr. *serpentine*, Sp. *serpentin*, It. *serpentino*; so-called after the adjective serpentine; resembling a serpent; winding and turning one way and the other, like a moving serpent; anfractuous; crooked; meandering; spiral.]

Mineralogy and Petrology.—A mineral or rock consisting chiefly of the hydrous silicate of magnesia, and usually of an obscure green colour, with shades and spots arising from the presence of small quantities of chromic iron, which give it a spotted or mottled appearance resembling a serpent's skin. The finer varieties called *precious* or *noble serpentine*, are translucent, and of different shades of rich oil-green colour, usually dark, but sometimes pale (DANA).

EXPLANATION OF PLATE.

THE LIZARD SERPENTINE.

From a Quarry between Kynance Cove, and Lizard Town.¹
× 25 diameters.

On the left hand side of the picture, part of a large crystal of enstatite is shown *e'*; the upper portion of this crystal marked *a*, belongs only apparently to it; in reality it is entirely distinct from it, and polarises on a different plane and in different colours; it behaves in a manner analogous to crystals of undoubted augite which obtain in other parts of the field. *e*., smaller crystal of enstatite; *o*., nucleus of olivine.

DESCRIPTION.

In an appendix to BONNEY's paper on the serpentines and associated rocks of the Lizard district,² HUDLESTON has shown that however diverse the serpentines may be in outward appearance of colour and texture, they yield, on chemical analysis, results which are strikingly similar; so, under the microscope, those widely different physical aspects become wonderfully diminished, until, with the use of polarised light, the dark green variety streaked with blackish red, and all the intermediate varieties which lead up to a chocolate coloured rock with strings of yellowish green and patches of silvery grey, seem to be identical. The identity is manifested thus:—Those portions of the rock, which with the use of ordinary transmitted light are seen to be of various shades of yellowish green, more or less mottled with grey, assume bluish-white and neutral tints under crossed Nicols, and are thus shown to be true serpentine. The deeper reds, yellowish reds, and blackish streaks, spots, and patches, remain uniformly dark under completely polarised light; they indicate the finely granular deposition of iron (occasionally limonite, but chiefly hæmatite) within the rock; this may be detected with a power of about 300 diameters.

But in addition to all this, other constituents may invariably be found; the most noticeable amongst these are crystals, usually of definite structure, which every here and there stud the otherwise fine groundwork and impart a porphyritic texture to it. Some of these crystals remain tolerably fresh, as in the case of the section from which the illustration was taken; but, in the vast majority of instances they lose their original limpid character and assume an earthy texture and greenish to yellowish hue, whilst they retain their primary forms. These changes

¹For the specimen from which the drawing was taken, I am indebted to the kindness of Mr. C. R. LINDSEY, of Salford.

²*Quarterly Journal of the Geological Society, London, 1877, vol. xxxiii.*

may be heralded by the invasion of numerous fissures which traverse the body of the crystal indiscriminately. Along these *fissures of metamorphism*, as well as through the borders of the crystals, their substance becomes converted into an amorphous greenish material, which often becomes fibrillated, and gives the reaction of serpentine with crossed Nicols. Sometimes no trace of fissuring is evident; it may be noticed, however, that the fibrous green change has been superinduced along the cleavage planes, and from these a kind of centrifugal propagation of that change has supervened. In many instances the crystals polarise in strong colours, even where the metamorphism has seemingly been completed; and, according to BONNEY¹, they are examples of enstatite. But besides the enstatite, other crystals obtain, which, under polarised light, behave in a manner precisely similar to the augite of other rocks, especially of the pikrite,² which has already been described.

In some well preserved examples, where the metamorphism of the rock has not advanced quite so far as to destroy all vestiges of its freshly crystalline texture, the augite partakes of the character of diallage, and may with justice be termed *diallagic-augite*.³

It is only in exceptional cases, as in the section from Coverack Cove, figured by BONNEY,⁴ that any distinct outline of olivine is recognisable; every specimen, however, of serpentine from the Lizard contains abundant traces of olivine in small fresh nuclei wrapped up in the meshes of the network of iron. The iron is chiefly hæmatite, sometimes limonite; it forms interlacing strings, which, with a high power may be resolved into closely aggregated granules of a dark red or reddish-yellow colour; thus viewed, each mesh is seen to surround a central fresh colourless nucleus (somewhat like frosted glass), and this is usually bordered by a rim of greenish serpentine. The central clear nuclei are fresh olivine; with polarised light they change from a rich crimson through shades of peacock blue to green, and thus call to mind the olivine of the pikrite of Inchcolm. In contradistinction to this, the enstatite which may occasionally become similarly enclosed in the network of iron, gives a play of colours from bright azure to orange, as in the larger examples.

BONNEY regards the serpentine of the Lizard as the metamorphosed result of a Lherzolite, for he has detected in various specimens, minerals which show it to have been mainly composed of olivine, enstatite, and picotite, in only one specimen, viz., that of Gue Graze, has he found any felspar.⁵ My observations lead me to view the rock as an altered pikrite of the Inchcolm variety, a rock closely allied to Lherzolite. I have found several examples which show the alteration of that rock into a distinct serpentine, and, since the paper on pikrite appeared, have come across one or two sections showing occasional crystals of a triclinic felspar (labradorite?).

For the methods of preparation, and literature on the subject, see this journal pp. 54-64.

¹*Op. cit.*

²*Ut supra*, p. 49.

³See BORICKY, *Petrographische Stud. a. d. Melaphyr-Ges. Böhmens*, Prag, 1876, p. 19.

⁴*Op. cit.*

⁵*Op. cit.*, p. 918.



J. W. Watson, del. ad nat.

T. S. LARGE INTESTINE OF DOG.

J. W. Watson, del. et lith.

X 25

THE ALIMENTARY CANAL.¹

THE LARGE INTESTINE.

Etymology.—See this Journal p. 299. **Anatomy.**—The large intestine is divided by anatomists into three chief portions. The first part termed the *cæcum*², forms a wide but very short tube in man; it terminates blindly, in an extremely attenuated hollow prolongation, which, from its shape, has been called the *vermiform appendix*; this structure is confined to man, the higher apes, and the wombat, but it reappears in a somewhat less pronounced though larger form in the rabbit and its congeners. The *colon*³, or second portion, commences at the *cæcum* opposite the ileo-cæcal valve, and ends in an S-shaped part, its sigmoid flexure, to enter the *rectum*⁴, or third and final section of the large intestine.

EXPLANATION OF PLATE.

T.S. LARGE INTESTINE OF DOG.

× 25 diameters.

c., crypt of LIEBERKÜHN cut vertically; *c'*., crypt of LIEBERKÜHN cut transversely; *mm.*, muscularis mucosæ shown raised up on each side of a solitary lymphoid follicle *l.*; it is discontinuous at the summit of the follicle; *s.*, submucosa; *m'*., circular muscular coat; *m''*., longitudinal muscular coat; *a.*, plexus myentericus of AUERBACH.

DESCRIPTION.

The membranes of the small are in direct continuity with those of the large intestine; they are essentially similar, but present certain differences in structure (observable in progression from the proximal to the distal or anal extremity) which arise as adaptations to the varying functions of each section. Thus the villi of the small are altogether absent from the mucous membrane of the large intestine, and, in consequence of this, its vascular systems become considerably modified towards their periphery, and thereby their secreting and absorbent functions are modified.

¹Continued from p. 302.

²Lat. *cæcus*, blind, concealed; Ger. *blinddarm*.

³Lat. *colon*, *colum*; Gr. *κωλον*, limb, member, especially the largest of the intestines.

⁴Lat. *rectus*, straight; so termed by the older anatomists who described it first in the lower orders of the *Mammalia*. In man the rectum is far from being straight.

Although villi do not pertain to the large intestine, minute papillary growths of the mucosa may sometimes obtain, as in the colon of the rabbit. These papillæ, however, are not strictly comparable to the villi, since they are surmounted by the surface epithelium with its numerous crypts of LIEBERKÜHN, as in the rest of the large intestine.

According to KLOSE¹ the epithelial cells of the mucous membrane assume the appearance of ordinary columnar cells after active secretion, both on the surface and within the crypts of LIEBERKÜHN; under normal conditions the cells of crypts are more mucoid than those of the surface. In the rabbit all these cells are distended with mucus; in the dog only alternate cells are so affected. In all other respects the epithelium is similar to that of the small intestine. In intimate structure, the mucosa resembles that of the small intestine.

The muscularis mucosæ is usually disposed in an inner circular and an outer longitudinal layer of non-striped cells, although either stratum may be absent. Of interest are the minute offshooting fasciculi which may sometimes be seen to leave the inner zone, and to ascend between the crypts of LIEBERKÜHN; in the colon of the rabbit, these muscle cells penetrate the minute papillæ which occur in that structure, and on reaching their apices are inserted in the basement membrane underlying the epithelium (WATNEY²).

The submucosa is like that of the small intestine; if a distinction can be drawn between them, that of the large intestine may be said to possess a relatively greater amount of adipose tissue. This portion of the structure lodges the lymphoid glands, which generally pertain as solitary follicles, and are commonly larger than those of the small intestine. One of these follicles is depicted in the illustration, and shows in a typical manner the relation which usually subsists between it and the circumjacent tissues. The follicle is shown as an eminence projecting through the mucosa; its summit has reached the epithelial layer, and induced a degeneration of the crypts of LIEBERKÜHN and boundary epithelium; in the mucosal region its body passes gradually into the adenoid reticulum of that structure. The muscularis mucosæ also is raised up on each side of the follicle, and the growth of the latter has occasioned a breach through which its summit protrudes into the mucosa. In the pig, and occasionally in man and the dog, the structures which overlie the follicle are drawn down towards its more deeply seated summit; there thus results a superficial pit, instead of an eminence, into which the mucosa and epithelium are drawn down. Where many follicles are aggregated a PEYER's patch results; in the cæcum of the rabbit these are well shown, and the vermiform appendix of man and other animals, contains many such follicles compactly disposed. In a PEYER's patch the follicles are precisely similar to the one already described; their proximity, to each other, causes their bodies to become confluent whilst their summits and bases remain distinct from one another; these phenomena may be readily observed in the cæcum of the rabbit, the lower part of the ileum in the dog or cat, or the processus vermiformis where that organ obtains.

¹*Inaug. Dissert.*, Breslau, 1880.

²*Phil. Trans., Royal Society*, London, 1876.

The muscular tunic of the large intestine consists of an inner circular and an outer longitudinal coat; neither of these layers are regularly disposed. The circular coat forms groups in the septa of the sacculi of the colon, whilst the longitudinal coat is parcelled out into strips (the so-called ligaments), which are shorter than the entire length of the intestine; this causes the sacculation of that viscus, for when the longitudinal bands are removed by dissection the sacculi disappear. The rectum forms an exception to what has been stated, in the possession of a well-developed coat of uniform thickness, its circular layer is very thick; its mucosa also is largely represented.

The serous coat of both the small and the large intestines, is continuous with the two layers of the mesentery which are reflected over the intestinal tubes at all parts except a small linear portion where the vessels and nerves enter, and which has been termed the *attached* or *mesenteric border*. It is essentially a part of the peritoneum. Along the colon and rectum it gives rise to numerous small projections which include an amount of fatty tissue, and are known as *appendices epiploicæ*.

THE BLOOD-VASCULAR SYSTEM is arranged in both the small and large intestines in several systems, which agree with the distribution of those structures in the stomach, in all essential details. Each portion is provided with its own vessels; thus separate systems supply the mucous membrane proper, the lymphoid follicles, BRUNNER'S glands, the muscularis mucosæ, the external muscular coat, the fatty tissue of the submucosa, and the serous coat.

Within the submucosa are situated the larger arterial and venous twigs, from which the contained and superjacent tissues are supplied. The capillaries and veinlets of the external muscular coat also pass to the larger vessels of the submucosa; they are arranged in an elongated meshwork of minute vessels, as in all non-striated muscular tissues. The serous coat is provided with a uniform network of capillaries as in the mesentery, and the fatty tissue and glandular elements do not differ in this respect from other similar structures.

The solitary and agminated lymph follicles are provided with elongated capillary meshes, which extend towards the centre of their bodies, and there form loops. The individual follicles are surrounded by a fine network of veinlets (KLEIN¹).

The most important system, however, is that which is distributed over the villous surface of the small intestine. The researches of HELLER² have shown that from the arterioles of the mucosa there arise numerous capillaries. These form networks, with elongated vertically-disposed meshes, around the crypts of LIEBERKÜHN. In the villus, the arteriole passes up towards the apex (in man it ceases near the lower half), where it breaks up into a network of capillaries, which is denser at the summit than at the base of the villus. The capillaries of the villi anastomose

¹*Atlas of Histology*, London, 1880, p. 221.

²*Ber. d. Sächs. Ges.*, 1872.

with those of the rest of the mucosa. The veins commence near the apex of the villus in man and in the rabbit; in the dog, cat, hedgehog, and pig, they take their origin near its base.

THE LYMPHATIC SYSTEM.—The lacteal vessels of the mesentery give off branches, which enter the intestine at its mesenteric border, and pass into its external muscular coat, there to be resolved into a plexus, which pervades its entirety, and which becomes most marked between its two layers. In direct continuity with this system is that of the mucous membrane, which forms a dense plexus throughout the mucosa and submucosa; some of its vessels are perivascular. At the bases of the lymphoid follicles a close plexus which often dilates into sinuses obtains. Many lymphatics also are developed at the attachment of the serous coat with the boundaries of the external muscular zone. In the small intestine each villus possesses a central lymphatic or chyle vessel, or two such vessels may become confluent to terminate blindly within the villus; towards its base the chyle tube becomes narrower and enters the plexus or sinuses between the crypts of LIEBERKÜHN.

THE NERVOUS SYSTEM.—The nerves enter the intestines at their mesenteric borders, and penetrate their external coats to produce a gangliated plexus between the longitudinal and circular muscular layers. This, the *plexus myentericus* of AUERBACH consists of bands of non-medullated fibres, ensheathed in an endothelial membrane derived from the perineurium of the nerve trunks. Every here and there irregularly shaped spaces obtain which contain ganglion cells in chains, rows, or nests; these may be unipolar to multipolar, and only the larger ones are capsulate. The muscular coats are penetrated throughout by a fine plexus of fibrils derived from this large plexus. Other larger bundles of fibrils proceed to the submucosa, where they form a finer plexus—the plexus of MEISSNER, which in its turn gives off still finer branches, to be distributed throughout the mucosa, and reach the epithelial surface. In the large the plexus of AUERBACH is somewhat more highly developed than in the small intestine.

METHODS OF PREPARATION.

The fresh intestines should be washed out with a stream of water, or of normal saline solution, to get rid of the mucus which usually adheres to the epithelial surface; small pieces may then be hardened in chromic acid and spirit fluid, in ordinary rectified spirit, or, best of all, in ammonium bichromate solution.¹ The sections may be stained with logwood, and mounted in Canada balsam or dammar solution.

The blood-vessels may be injected through the aorta, or the superior mesenteric artery, by methods, and with fluids which have already been described.²

The lymphatics, especially those of the processus vermiformis, may be injected with a watery solution of Berlin-blue by mean of a hypodermic syringe thrust into the walls of the structure. The hardening of

¹*Ut supra*, p. 264.

²See this journal, pp. 85, 219, etc.

such preparations is best effected in rectified spirit. Sections may be stained with picrocarmine, and mounted in Farrant's solution. An injection of silver nitrate may also be used in the same way; the silver becomes reduced in the cement substance of the cellular elements.

The nervous system requires a special mode of treatment for its effective demonstration. A portion of perfectly fresh intestine should be distended with fresh lemon juice, its cut ends ligatured, and the whole suspended in the same fluid for from five to seven minutes. The lemon juice must now be entirely removed by washing in distilled water, and replaced by a two per cent. gold chloride solution for about half-an-hour. Every trace of the gold must then be removed by rinsing in distilled water, and the tissues placed in a twenty-five per cent. formic acid fluid until the gold has been reduced to a reddish-brown colour. Now, wash the piece of intestine thoroughly in water, and place it in ordinary methylated spirit, or diluted glycerine, to which a few drops of carbolic acid have been added, for a week. At the end of that time, the longitudinal muscular coat with the adherent plexus myentericus of AUERBACH may be readily stripped off with the use of a pair of forceps, and mounted either in Farrant's solution or glycerine. The plexus of MEISSNER may be prepared in a similar way. by teasing the tissues of the submucosa.

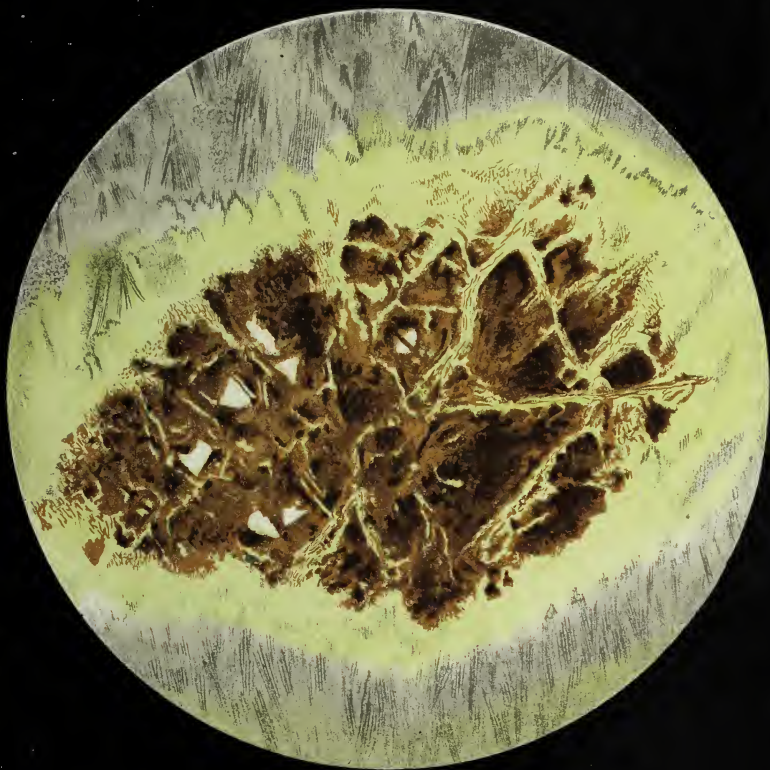
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del ad nat.

J.W. Watson del et lith.

SERPENTINE
Portsoy, Scotland.
X 25

SERPENTINE.

PORTSOY.

× 25 diameters.

EXPLANATION OF PLATE.

The illustration shows a transmuted crystal of augite, fragmentary in appearance, from a double system of intersecting rents, which accord roughly with the cleavages of the unaltered mineral. These fragments are surrounded with a quantity of ruddy dust, sprinkled in an enveloping expanse of flakey yellow serpentine. Parts of the slice show a cincturing zone of divergent acicular crystals, which are sometimes disposed in brushes in a confused magma of a clouded pale yellow tint; this is an altered asbestiform mineral approaching nephrite in structure. Occasionally veins of super-hydrated or "precious" serpentine cross the field. (HEDDLE.)

DESCRIPTION

by

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"A mysterious rock;" the finding of the early geologists.

To many of those who dandle the microscope into power, as an instrument of precision, regarding it with its pleasant associates of easy couches and revolving tables, as the *open sesame* to a royal road to knowledge, there is no mystery at all.

The present writer, five years ago, after having carefully inspected almost every serpentine locality in Scotland, made a contribution to the ascertained facts connected with the rock in a paper of a hundred quarto pages, which contained sixty-two original analyses. In this, taking for granted, as a generally admitted dictum of science, that the conversion of olivine into serpentine had been established for fifty years, he ventured to show how minerals, other than olivine, might also be transmuted into it. He endeavoured to show that the spirit of partisanship in no way influenced him, by writing—"it has to be remarked, in the first place, that as the above analyses of these alterative products were made in the course of a progressive examination of all uncertain minerals, and in no way with the object of determining the nature of what has been unfortunately designated the "magnesian process," these analyses come forward as altogether unbiassed witnesses as to what that process has been. They were not selected from the rock as specimens suitable or likely to prove any theory whatever, but were simply chosen as the best obtainable illustrations of things the nature of which it was desirable to determine."

The sentences—"while it is much to be desired that a still more extended series of analyses be undertaken to throw more light on this matter;" and "I would suggest the following explanation of the serpentinous formation of these pseudomorphs"—vouch for a due recognition of the difficulties of the subject, and a wholesome amount of scientific diffidence.

Shortly after the issue of this paper, a voluntary criticism thereof was vouchsafed to the author by a fellow-worker in the same field; one who claimed, and worthily claimed, great experience. It ran in these words: "Perhaps I may be forgiven for saying that my studies of serpentine have led me to conclusions quite opposite to yours, viz., that true massive serpentine is, in all cases, the result of the alteration of a rock, mainly peridotite, and that I have never seen the slightest evidence in favour of, and much against, the possibility of its being formed from an augitic or hornblendic rock."

This is emphatic, positive, and clear. On the one side there is observation, the balance, and induction; on the other, observation, the micro scope, and inference.

The question is,—is serpentine "in all cases the result of the alterations of a rock mainly peridotite," or may it not, in addition to that source, sometimes result from the alteration of gabbro, euphotide, and diorite,—of gneiss or gneissic schists, *as rocks*; of enstatite, diallage, malacolite sahlite, augite, and hornblende, *as minerals*.

Who shall decide? And, in the first place, who shall say *what serpentine is*? Here the question clearly concerns it as a *rock-mass*, not a mineral; it is the geologist who is to speak, not the mineralogist or chemist; and the geologist, until he admits error, is to abide by the rocks which he himself has written of, or spoken of, as serpentine. I quote from two writers as regards the rock mass, and the constituent minerals which severally have been changed, and I refer to others as regards the rationale of the formation.

COTTA writes:—"The rock serpentine appears to be nearly if not always a product of transmutation derived from other rocks, as granite, gneiss, gabbro, chlorite, schists, &c. Its right to the character of an independent mineral is open to doubt, as it frequently appears to be only a pseudomorph after other minerals, *e.g.*, hornblende, augite, garnet, spinel, &c."

An examination by J. KÜHN (*Jahrb. f. Min.*, 1882, 2 Ref., 63-64), of specimens of ophite from over 100 localities has, in the words of a reviewer in the *Journal of the Chemical Society*,—"resulted in the harmonising of various results obtained by other authors whose examinations have not been so extended. The essential constituents are ordinary augite, 'diallage like augite,' diallage uralite, viridite, felspar, epidote, titanite iron; as accessories are, magnitite, pyrite, hæmatite, apatite, hornblende, quartz, calcite, and Biotite."

The above harmonising of results has certainly in neither case given marked prominence to a formation from *olivine*, seeing that substance is not even mentioned.

As bearing upon the nature of the change which produced serpentine, being such that it cannot be produced from "a rock mainly peridotite," I need do no more than cite DR. STERRY HUNT's views of the origin of the serpentines of the Laurentian rocks in Canada; GUSTAV ROSE's views as to the serpentine of the schistose rocks of Silesia; MESSRS. ROWLEY and KING's views of the Irish serpentine; PROFESSOR JAMES GEIKIE's views of the rock in Ayrshire; and MR. DOBBIE's views as to the incipient changes in the dolomite at Campsie.

Only by returning to the finding of the early geologists, that "serpentine is a mysterious rock," can we in harmony hope to solve the mystery. Assuredly will it be found that it is not the microscope and the balance which are out of harmony, especially if they are in the hands of the same enquirer. Doubtless much of the conflict of opinion which obtains regarding the primal source of serpentine, results from the term having been either loosely applied, or applied without any determination as to whether the rock was a hydrated silicate of magnesia; and doubtless, some of the granitic serpentines will prove to be of the nature of agalmalolite; while those considered to be of gneissic origin may be even less deserving of the name. Still, there rests in the mind of the writer, not the shadow of a doubt that the serpentines of Scotland, with which he is familiar,—and which, though markedly diverse in appearance, are equally entitled to the name,—have been formed through an alteration of altogether dissimilar rocks.

He holds firmly that several are formed from igneous rocks; but these are in comparatively small amount, generally mere dykes. In these igneous serpentines the proneness of olivine to change has probably determined or prompted the alteration of the rock-mass as a whole. Still the olivine of Scotch "traps" much more frequently changes into the true *ferrite*, or into a saponitic or bole-like substance, than into simple hydrated silicate of magnesia. There is, moreover, this marked characteristic of Scotch *igneous serpentines*, they have neither such pronounced features, nor such distinct "beauty spots," as those formed from other rocks.

The Shetland, the Glen Urquhart, the Portsoy, the Strath Don, the Glen Tilt, and the Kinnordy rocks, must all stand as Serpentine; for all have been written of as such, and each and all have been utilised as such. With the exception of the last, not one of these does the writer believe to have been *directly formed* from an igneous rock. The Portsoy, Strath Don, and that series, possibly were primarily intercalated beds of igneous origin, which have been subsequently metamorphosed along with all the rocks of the district, and finally serpentinised. The Glen Tilt, if claimed by STERRY HUNT, GEIKIE and DOBBIE it will not be easy to dispossess them of. While it may be safely said of the Shetland, that it manifestly results from the changes of gabbro.

The marked distinction between these rocks and English (Lizard) Serpentine, is either the absolute or the comparative absence of olivine. If the really insignificant crystals present in some igneous rocks be excepted, olivine must be said to be a very rare mineral in Scotland. Neither in the unaltered gabbro, nor in the serpentine, have I seen a

trace of it in Shetland. Doubtless it is the weakness of science, but so it is,—we hunt up or run down the rare things. The writer is peculiarly strong in that weakness; he hunts up and has run down a good many rare things in Scotland; but two that have almost beat him are the chief factors in serpentinic formation,—olivine and enstatite. Schiller-spar he has found at three localities; enstatite *never*,—at least unchanged into serpentine; and when it is changed into serpentine, the writer admits that unless he gets it in proper position, he is unable to discriminate between such enstatite serpentine and diallagic serpentine.

Speaking only of substances which he has analysed, he has to say that the minerals which go generally to form serpentine in Scotland may be recognised by presenting four varieties of structure in the skeleton forms which appear to have been the original crystal components of the fabric.

These structures are impressed upon each transmuted substance through the agents of decay, and the agencies of change alike—operating along lines of weakness. Cleavage faces are the directions in which cohesion operates with least force; in these directions the shocks of grinding strain the specimen; while along these directions the substance can offer a feeblor resistance to the attacks of transmutation.

From more or less of a crude resemblance thereto, I shall term these structures the *ovoidal*, the *herring-net*, the *rabbit-netting*, and the *grid-iron*.

The first belongs to malacolite, as seen in primitive limestones; the second to sahlite and augite; the third to olivine; the last to diallage.

The ovoidal, when cut at right angles is circular or tube like: it results from surface change in the small and rounded imbedded crystals of the mineral. At a later stage of the process, the central unaltered malacolite is crossed by bands of connecting serpentine, in more or less parallel and sharp-angled arrangement. The herring net structure is the result of the intersection, at angles of $87^{\circ}5'$, and its complementary angles, of the dominant *cleavage* of the augitic mineral, under change. Olivine having only *one cleavage*, is pervaded by a system of *cracks*, which are disposed, more or less, after the manner of the shrinkage-rents of basalt and of starch. As the rending here takes place from all the surfaces indiscriminately, or, perhaps, from the surfaces of shock, during preparation, these rents are seen in whatever directions the original crystals may be sectioned. As there are two directions in which either one or other of the subsidiary cleavages of augite form, along with the dominant cleavage, a six-sided cleavage form, serpentinised augite, when sliced in that direction, bears a resemblance to serpentinised olivine. It may generally, however, be distinguished by the straightness of the lines of rent; the continuance of these in more or less of parallel arrangement for some little distance across the crystal; and by the definiteness of the intersecting angles, as compared with those seen in the altered olivine. Other slices of augitic serpentine from the same rock, moreover, will show only the net-like cleaving.

The grid iron structure is the result of the specially perfect cleavage of diallage. Another fairly well-marked distinction between olivine-serpentine and augite-serpentine is that the residual fragments of the former,—

clear or opaque,—are surrounded by a sheath of clear serpentine ; while the generally-clouded fragments of transmuted augite are merely disconnected, or, at the fringes of the blotch of opacity appear as a sprinkled dust minute in grain, disposed in the centre of a wide expanse of hyaline material. Scotch augitic-serpentine might almost be distinguished from English by its transmutation products. First there is a prevalence of a mantle of diverging acicular crystallisations. These are so marked that BREWSTER regarded them as the true crystal of the mineral. Second, there is a clouded yellow-white mass, which includes isolated brushes of the crystals. Third, there are true secondary veins equally coated in the sides with a pellucid material, which, with transmitted light, has a girasol appearance. Fourthly, there are veins of true chrysotile, with the fibres always in arrangement parallel to one another, but transverse to the vein. These fabrics grow from one side only of the vein. And, lastly, there is in Scotch serpentine many more veins of calcite than in the English or the foreign.

At Portsoy there are many beds of serpentine, so distinct in feature that it would be altogether irrational to assign them to one parent rock.

Taking them as they occur from west to east—that is rising in the section—the first great mass itself shows three varieties as different in appearance as any serpentines in the kingdom.

Its lowest bed, which has been worked back, until the safety of the road called for cessation, is pale green to pale yellow in its mass, studded with red or chocolate-tinted crystals. The central portion is dark green, mottled with white, and seamed with masses of apparently a pale yellow nephrite. The upper is a dusky verdigris-green mud, with dark blue dendritic markings.

From the first or lowest were the specimens, which are figured, derived. From this bed chiefly were obtained the magnificent pillars of the great Salon of the Palace of Versailles.

The writer has been able to separate and analyse, with a single exception, all the alternative products mentioned above.

The slice shows a portion of one of the imbedded red crystals, fragmentary in the centre, with its blotchings and sprinkling of ruddy dust ; the surrounding expanse of hyaline yellow serpentine ; the envelope of radiating acicular crystals ; while part of some of the slices will show the clouded but much altered nephritic mineral, in which lie imbedded brushes of the acicular crystals.

Of these structures the nephritic substance, and the ruddy material have been analysed. The latter is frequently in large clearly defined pseudomorphous crystals, which have oblique terminations ; and hence had been, without doubt, augite. They were first cut out of the rock, all adherent pale material cut off, and then gently crushed by a pestle of hard wood in an agate mortar. From the soft and smooth powder the unaltered chips were removed with the fingers, so that the substance must have been fairly uniform.

It so appeared under the microscope ; and it was fully as deep in colour as it appears in section.

Its analysis yielded :—

Silica ...	...	...	...	37·327
Alumina ...	...	...	...	1·13
Ferric Oxide ...	...	...	...	4·357
Ferrous Oxide ...	...	...	...	4·047
Manganous Oxide ...	...	...	...	·384
Lime ...	...	...	...	1·204
Magnesia ...	...	...	...	36·712
Potash ...	...	...	...	·875
Soda ...	...	...	...	·734
Water ...	...	...	...	13·374

100·144

So that this substance, instead of being hematite or limonite, as is generally supposed, is merely an *iron serpentine*, that is, an hydrated augite, from which the lime has been removed, and the iron partly peroxidated.

I must, indeed, protest against terming the deep colouring matters of serpentine, hæmatite and limonite. Both of these are *minerals*, with a definite structure, it is quite possible that the dusty powder which stains some serpentine may be *amorphous ferric oxide*, or *hydrated ferric oxide*; but, unless it shows either a radiated or a definitely crystalline form, it is neither hæmatite nor limonite.

The above analysis, with the rich oily appearance of the substance itself, throws some doubt upon oxides of iron, other than magnetite, existing free in the rock.

These pseudomorphs of augite sometimes lie directly imbedded,—with very little of the flake-like yellow zone,—in what has the appearance of a hydrated asbestos or nephrite. This is pale yellow in colour, and when in mass is frequently cut across by veins of rich green precious serpentine.

It presents somewhat varying appearance as its matted fibrous structure becomes more and more obliterated. It is excessively tough, and has a specific gravity of 2·388.

Three specimens which seemed to show a progressive passage into serpentine were analysed: the first only partially, that in which the change seemed furthest advanced, completely. The first was very tough; the last unctuous to the touch.

	1	2	3
Silica .....	... 46·716	... 46·923
Alumina .....	... ·625	... ·633
Ferric Oxide .....	... ·007	... ·007
Ferrous Oxide.....	... 1·712	... 1·674	
Manganous Oxide .....	... ·71	... ·769
Lime .....	...not deb.	... 9·907
Magnesia.....	... 25·758	... 25·846	
Potash.....	·567	... ·567	
Soda	·57	... ·582	
Water ...	9·0	... 12·84	

99·748

Whether this substance had been asbestos or not the analysis does not make clear; it is, however, evident that it has not been changed to the same extent as had the augite, nearly 10 per cent. of lime remaining.

APPENDIX.

SECTION A.

ANIMAL HISTOLOGY.

- PAGE 1.—l. 15 from foot of page ; for “(*Elasmobranchii*)” read “(*Elasmobranchii*).”
- PAGE 3.—l. 2 from foot of page ; for “MULLER” read “MÜLLER.”
- PAGE 5.—l. 23 from top of page ; for “HOGAN’S” read “HOGGAN’S.”
- PAGE 5.—l. 14 from foot of page ; for “neuclei” read “nuclei.”
- PAGE 22.—l. 18 from top of page ; for “*vitreous layers* by GLASTAFELN” read “*vitreous layers* (Ger. Glastafeln).”
- PAGE 24.—l. 6 from foot of page ; for “was” read “saw.”
- PAGE 70.—l. 22 from top of page ; for “wits” read “with.”
- PAGE 79.—last line ; for “racomose” read “racemose.”
- PAGE 81.—l. 10 from foot of page ; for “iver” read “liver.”
- PAGE 97.—l. 6 from top of page ; for “lymphiod” read “lymphoid.”
- PAGE 111.—l. 17 from foot of page ; for “efferent” read “afferent.”
- PAGE 121.—l. 18 from foot of page ; for “admits” read “admit.”
- PAGE 123.—l. 16 from top of page ; for “sulph-indigotate” read “sulph-indigotated.” l. 10 from foot of page ; for “points” read “point.”
- PAGE 158.—l. 8 from top of page ; for “herinafter” read “hereinafter.” l. 19 from foot of page ; for “layer low” read “layer of low.”
- PAGE 160.—l. 8 from top of page ; for “them a” read “them in a.”
- PAGE 220.—l. 17 from top of page ; for “182” read “1882.”
- PAGE 229.—l. 26 from foot of page ; for “lymphoid cell” read “lymphoid cells.”
- PAGE 258.—l. 3 from foot of page ; for “ür” read “für.”
- PAGE 264.—ll. 9, 10, from top of page ; for “lympathic” read “lymphatic.”
- PAGE 281.—l. 3 from foot of page ; for “Uber” read “Ueber.”
- PAGE 283.—l. 9 from foot of page ; for “mucosa” read “mucosæ.” l. 6 from foot of page for “mucosæ” read “mucosa,” and for “muscularis mucosa” read “muscularis mucosæ.”
- PAGE 284.—l. 11 from top of page ; for “layer” read “layers ;” and for “branche” read “branches.” l. 4 from foot of page ; for “*Saugadersystem*” read “*Saugadersystem*. ”
- PAGE 288.—ll. 14, 15 from foot of page ; for “glanduar” read “glandular.”
- PAGE 292.—METHODS OF PREPARATION should be placed below l. 6 from foot of page. l. 8 from foot of page ; for “plexuf” read “plexus.”
- PAGE 299.—l. 18 from top of page ; for “gland of BRUNNER” read “glands of BRUNNER.”
- PAGE 300.—l. 9 from top of page ; for “mucosæ” read “mucosa.”

APPENDIX.

SECTION B.

BOTANY AND PETROGRAPHY.

- PAGE 9.—l. 6 from top of page ; for "A.S." read "A-S," and for "*benk*" read "*beuk*." l. 7 from top of page ; for "*poucha*" read "*puocha*," and for "*bouche*" read "*buoche*."
- PAGE 10.—l. 25 from foot of page ; for "into an equivalent number" read "into a number of equivalent."
- PAGE 12.—l. 10 from foot of page ; for "*Sapindocce*" read "*Sapindaccee*."
- PAGE 13.—l. 9 from top of page ; for "NAGELI" read "NÄGELI."
- PAGE 16.—l. 29 from foot of page ; for "NAGELI" read "NÄGELI" l. 15 from foot of page ; for "*Bau*" read "*Bau*."
- PAGE 17.—ll. 22, 23, 36, from top of page ; for "NAGELI" read "NÄGELI." l. 5 from top of page ; for "*und Verwandten*" read "*und die verwandten*."
- PAGE 18.—l. 2 from top of page ; for "*Surles*" read "*Sur les*." ll. 21, 22, from top of page ; for "NAGELI" read "NÄGELI." l. 18 from foot of page ; for "*Suberisce*" read "*Suberised*." ll. 28-17 from foot of page, should come between ll. 8-6 from foot of page.
- PAGE 29.—l. 6 from top of page ; for "Κμπειρος" read "Κύπειρος."
- PAGE 44.—l. 7 from top of page ; for "λίδος," read "λίθος."
- PAGE 45.—l. 16 from foot of page ; for "LASLAUX" read "LASAULX."
- PAGE 46.—ll. 2, 17 from top of page ; for "LASLAUX" read "LASAULX." l. 15 from foot ; for "chrysolite" read "chrysotile."
- PAGE 54.—l. 15 from foot of page ; for "GIRKEL" read "ZIRKEL."
- PAGE 55.—l. 7 from top of page ; for "LASAUBX" read "LASAULX."
- PAGE 62.—l. 19 from foot of page ; for "FOUQÉ" read "FOUQUÉ."
- PAGE 89.—l. 6 from top of page ; for "containg" read "containing."
- PAGE 104.—l. 2 from foot of page ; for "*Thlapsi*" read "*Thlaspi*."
- PAGE 142.—l. 12 from foot of page ; for "*Helix hedera*" read "*Hedera helix*."
- PAGE 144.—l. 16 from top of page ; for "*Felix femina*" read "*Filix femina*."
- PAGE 151.—l. 6 from top of page ; for "λύκοος," read "λύκος." l. 7 from top of page ; for "ποδός" read "ποδός."
- PAGE 156.—l. 10 from foot of page ; for "ROPER" read "RÖPER."
- PAGE 175.—l. 22 from foot of page ; for "proto plasm" read "protoplasm."
- PAGE 187.—l. 13 from foot of page ; for "*endoearp*" read "*endoearp*."
- PAGE 188.—l. 18 from foot of page ; for "contray" read "contrary."
- PAGE 201.—l. 15 from foot of page ; for "and others, and are" read "and others, are." l. 12 from foot of page ; for "*fruticose*" read "*fruticose*."
- PAGE 213.—l. 17 from foot of page ; for "syntheses" read "syntheseses."
- PAGE 221.—ll. 12, 13 from foot of page ; for "linionitic" read "limonitic." On plate, for "Edinburgh" read "Edinburgh."
- PAGE 224.—l. 4 from top of page ; for "either" read "neither."
- PAGE 241.—On Plate ; for Fig. II. read Fig. III., and *vice versâ*. l. 2 from foot of page ; for "βλαστος" read "βλαστός."
- PAGE 251.—ll. 8, 7 from foot of page ; for "Haughtonite" read "Haughtonite."
- PAGE 252.—l. 20 from top of page ; for "They are not, etc.," read "That they are not, etc." l. 21 from top of page, for "as" read "is."
- PAGE 254.—l. 20 from foot of page ; for "yenite" read "syenite." l. 5 from foot of page ; for "coalescing" read "coalesce."
- PAGE 255.—l. 12 from top of page ; for "even a mile, etc.," read "even only a mile, etc." l. 12 from foot of page ; for "throw" read "thins."
- PAGE 256.—l. 14 from top of page ; for "which" read "while."
- PAGE 260.—l. 7 from top of page ; for "SACH's" read "SACHS."
- PAGE 275.—l. 10 from foot of page ; for "distinguishd" read "distinguished."
- PAGE 277.—l. 21 from top of page ; for "pottasium" read "potassium."
- PAGE 279.—l. 6, 7, from top of page ; for "*compestre*" read "*campestre*."
- PAGE 286.—l. 20 from foot of page ; for "envelop" read "envelops."
- PAGE 315.—l. 5 from top of page ; for "ROWLEY" read "ROWNEY."

INDEX.

SECTION A.

ANIMAL HISTOLOGY.

A.

Absolute alcohol, 208.
 Accipenser, 33.
 Acetic acid, action on cartilage, 3.
 Acrochordus, 34.
 Adelomorphous cells, 290.
 Æolidæ, 81.
 Air bladder, 147, 148.
 Air cells, 157.
 Air sacs, 149.
 Alimentary canal, 257-258, 261-264,
 271-274, 281-284, 287-292, 299-302,
 305-312.
 Alimentary canal, blood vascular sys-
 tem, 263, 283,
 292, 307.
 „ „ comparative anat-
 omy, 257.
 „ „ etymology, 257.
 „ „ intestines, 299.
 „ „ lymphatics, 264,
 284, 292, 308.
 „ „ nervous system,
 264, 284, 292, 308.
 „ „ œsophagus, 281.
 „ „ oral cavity, 261.
 „ „ pharynx, 281.
 „ „ preparation of, 264,
 284, 292, 308.
 „ „ stomach, 287.
 „ „ tongue, 271.
 Alveolar passages, 157.
 Ammocetes, 177.
 Ammonium bichromate, 70, 71, 264.
 Ammonium chromate, 136.
 Amœbæ, 257.
 Amphibia, 33, 147, 148, 178, 273.
 Amphioxus, 81, 82, 110, 147, 177, 197,
 218.
 Amphibœnoida, 34.
 Anableps, 178.
 Aniline dyes, 5.
 Annelida, 110.
 Anthozoa, 79.

Aphrodite, 80.
 Appendices epiplœicæ, 307.
 Apus, 80.
 Arachnida, 80.
 Arachnoid, 65.
 Argonauta, 81.
 Armadillo, 35.
 Arthropoda, 33, 80, 110.
 Artificial gastric juice, 39.
 Ascidia, 33, 82, 177.
 Auerbach's plexus, 292.
 Aves, 34, 149, 180.

B.

Balanoglossus, 80.
 Balantidium, 258.
 Basement membrane, 37, 301.
 Batrachia, 179.
 Bibliography of alimentary canal, 309-
 312.
 „ „ bone, 25.
 „ „ cartilage, 6.
 „ „ kidney, 137.
 „ „ liver, 98.
 „ „ lung, 168.
 „ „ salivary glands, 248.
 „ „ skin, 41.
 „ „ spinal cord, 71.
 „ „ spleen, 238.
 „ „ thymus gland, 200.
 „ „ thyroid body, 183.
 Bile-ducts, 95.
 Biliary concretions, 80.
 Blastocœle, 258.
 Blennii, 148.
 Blood-vascular system of alimentary
 canal, 263, 283, 292, 307.
 Blood-vascular system of kidney, 133.
 „ „ lung, 165.
 „ „ salivary
 glands, 247.
 „ „ skin, 38.
 „ „ spinal cord,
 70.

Blood-vascular system of spleen, 236.
 „ „, thymus gland 199.
 „ „, thyroid body, 182.
 Bohadschia, 79.
 Bojanus, organ of, 110.
 Bone-cartilage, 21.
 Bone, description of, 21-27.
 Bony plates, 34.
 Bopyrus squillarum, 80.
 Border cells of oxyntic glands, 290.
 Brachiopoda, 80, 110.
 Branchiopoda, 80.
 Bronchocèle, 181.
 Bronchus, 147, 149.
 Brunner's glands, 289, 300.

C.

Cæcum, 305.
 Calices of kidney, 112.
 Canaliculi of bone, 23.
 Carmine, 40.
 Carmine and sulph-indigotate of soda, 40, 182.
 Carp, 178.
 Carter's carmine mass, 219.
 Cartilage, bibliography of, 6-8.
 „ cells of, 2.
 „ comparative anatomy of, 1.
 „ development of, 3.
 „ elastic, 2.
 „ etymology of, 1.
 „ matrix of, 3.
 „ preparation of, 4.
 „ reactions of, 3.
 „ reticular, 2.
 „ spongy, 2.
 „ varieties of, 1.
 „ vessels of, 3.
 „ yellow-fibro, 1.
 Cat, 65, 93, 235.
 Cauda equina, 65.
 Caustic alkali, action of on cartilage, 3.
 Cement glands, 109.
 Central ligament of spinal cord, 65.
 Centroacinar cells of pancreas, 208.
 Centro-tubular membrane, 126.
 Cephalopoda, 1, 81, 110.
 Ceratophrys, 34.
 Cerebro-spinal fluid, 65.
 Cetacea, 35.
 Chamæleo carinatus, 179.
 Chamæleon, 34, 148, 179.
 Chelonia, 148.
 Chiton, 81.
 Chlamydomorphus, 35.
 Chondrin, 4.
 Chondrogen, 4.
 Chromatophores, 34.
 Chromic acid, 70, 160.

Chromic acid and spirit mixture, 40, 70, 83, 264.
 Chrzonszczewsky's method of natural injection, 97.
 Circumvallate papillæ, 273.
 Cirripedia, 80, 110.
 Cloacal glands, 34.
 Cockroach, salivary nerves, 248.
 Cocoa butter, 167.
 Cœcilia, 34.
 Cœlenterata, 79, 258.
 Colon, 305.
 Combs, 34.
 Concentric corpuscles of Hassall, 198.
 Copepoda, 80.
 Corium, 33, 37.
 Crania, 80.
 Craniota, 82.
 Crayfish, green gland of, 109.
 Crinoidea, 109.
 Crocodilia, 34, 148, 179.
 Crotalus, 34.
 Cuticle, 33.
 Cutis vera, 33, 37.
 Cuvierian organs, 79.
 Cyclodus, 34.

D.

Decapoda, 80.
 Delomorphous cells, 290.
 Derma, 37.
 Dibranchiata, 81.
 Didynium, 258.
 Diplœ, 22.
 Dipnoi, 148.
 Doridopsis, 81.
 Doris, 81.
 Duodenum, 299.
 Dura mater, 65.
 Dysteria, 258.

E.

Ecardines, 80.
 Echidna, 35.
 Echinodermata, 33, 110.
 Ectoderm, 33.
 Ectoplasm, 33.
 Edentata, 35.
 Eel, 178.
 Elasmobranchii, 1, 147, 178, 218.
 Elastic cartilage, 2.
 Elastin, 4.
 Enchondromata, 1.
 End bulbs, 38, 44.
 Endoderm, 81.
 Endoplasm, 33.
 Endostyle, 177.
 Endothelium, 261.
 Endothelial membrane, 261.
 Entomostraca, 80, 110.
 Eosin and logwood, 6.
 Epeira, 80.

Ephippifer, 34.
 Epiblast, 33.
 Epidermis, 33.
 Ether microtome, 4.
 Etymology of alimentary canal, 257.

 " " bone, 21.
 " " bronchus, 147.
 " " cæcum, 305.
 " " colon, 305.
 " " duodenum, 299
 " " fibro-cartilage, 1.
 " " human, 79.
 " " ileum, 299.
 " " intestine, 299.
 " " jejunum, 299.
 " " kidney, 109.
 " " liver, 79.
 " " lung, 147.
 " " œsophagus, 281.
 " " oral cavity, 261.
 " " pancreas, 205.
 " " pharynx, 281.
 " " salivary glands, 243.
 " " skin, 33.
 " " spinal cord, 65.
 " " spleen, 227.
 " " stomach, 257.
 " " thymus, 197.
 " " thyroid, 177.

Exocetus, 178.

F.

Feathers, 34, 43.
 Femoral glands, 34.
 Fibre, 1.
 Fibro-cartilage, 1.
 Filiform papillæ, 272.
 Filium terminale, 65.
 Food-vacuole, 257.
 Foraminifera, 257.
 Freezing microtomes, 4.
 Frog, thyroid body of, 178.
 Fundus glands of stomach, 290.
 Fungiform papillæ, 272.

G.

Gadidæ, 178.
 Gall-bladder, 82.
 Ganoidei, 147.
 Gasteropoda, 81, 110.
 Gastric juice, artificial, 39.
 Gastrula, 258.
 Gecko, 148, 179.
 Gianuzzi's crescents, 247, 263.
 Glans clitoridis, 38.
 Glæus penis, 38.
 Glisson's capsule, 82.
 Glomerulus, 122.
 Glycerine jelly, 4.
 Glycogen, 79.
 Goitre, 181.
 Gold chloride, 3, 5.
 Green gland, 109.

Gregarinidæ, 257.
 Gymnosomata, 81.
 Gymnotini, 148.

H.

Hæmatoidin, 238.
 Hairs, 35.
 Haversian canals, 22.
 Hepatic cells, 84.
 Hepatic lobules, 83.
 Hepatic vessels, 94.
 Hoggan, Frances Elizabeth, method of staining cartilage, 5.
 Holothuriæ, 79, 110.
 Hoofs, 35.
 Horns, 35.
 Hydra, 258.
 Hydromedusæ, 79.
 Hydrozoa, 33.
 Hypoblast, 33.
 Hypopharyngeal groove, 177.

I.

Ichthyodorulites, 33.
 Ichthyopsida, 111.
 Ileum, 299.
 Infusoria, 257.
 Injecting the liver, 98.
 Insecta, 80, 109.
 Intestines, 299.
 Iodine, action of on cartilage, 3.
 Isopoda natatoria, 80.
 Istiurus, 179.

J.

Jejunum, 299

K.

Kidney, 109-112, 119-126, 133-140.
 " bibliography of, 137.
 " blood-vascular system of, 133.
 " fresh, 135.
 " gelatine injected, 136.
 " hardening of, 136.
 " Ludwig's method for isolation of renal tubules, 135.
 " lymphatic system of, 135.
 " nervous system of, 135.
 " nitrate of silver injected, 135
 Klemenberg's logwood stain, 85.

L.

Labyrinthodonta, 34, 148.
 Lacertilia, 34, 148, 179.
 Lacunæ of bone, 23.
 Lamellæ of bone, 24.
 Lamellibranchiata, 80, 110.
 Lemon juice and gold chloride, 309.
 Lepidosiren, 148, 178.
 Lialis, 148.
 Lieberkühn's crypts, 300.
 Ligamentum latum pulmonis, 165.
 Limapontia, 81.

Limnadia, 80.
 Lingula, 80.
 Lip, red portion of, 38.
 Lister's method for observation of
 prickle cells, 38.
 Liver, 79-86, 93-102.
 Logwood staining, 85.
 Logwood and eosin, 6.
 Logwood and picrocarmine, 6.
 Loligo, 81.
 Ludwig's method of isolating renal
 tubules, 135.
 Lung, 147-150, 157-160.
 " blood-vascular system of, 165.
 " of eat, 165.
 " comparative anatomy of, 147.
 " framework of, 158.
 " hardening the, 160.
 " injecting the, 167.
 " lymphatic system of, 166.
 " minute structure of human, 157.
 " nervous system of, 166.
 " parenchyma of, 158.
 " preparation of, 159.
 " sheep's, 149.
 Lymphatic system of alimentary canal,
 246, 284, 292, 308.
 Lymphatic system of kidney, 135.
 " " " liver, 96.
 " " " lung, 166.
 " " " salivary glands,
 247.
 " " " skin, 38.
 " " " spleen, 237.
 " " " thymus, 199.
 " " " thyroid, 182.
 Lymphoid crypts, 274.
 Lymphoid follicles, 274.

M.

Macrostomum, 258.
 Malpighian cells, 157.
 " corpuscles, 121, 229.
 " layer of skin, 35.
 " pyramids, 112.
 " tufts, 110.
 " vessels, 109.
 Mammæ, 35, 43.
 Mammalia, 34, 35, 149, 197.
 Marsipobranchii, 33, 147.
 Medusæ, cartilage of, 1.
 Meissner's corpuscles, 35.
 Meissner's plexus, 292.
 Membrana propria, 179.
 Menobranchius, 178.
 Menopoma, 178.
 Mesoblast, 33.
 Mesoderm, 81.
 Metazoa, 33, 257, 258.
 Methylated spirit, 160, 208.
 Microtome, Groves's, 4.
 " Rutherford's, 4.

Microtome, Stirling's, 4.
 " Williams's, 4.
 Mollusca, 33, 41, 109, 110.
 Molpadia, 80.
 Morula, 258.
 Mucigen, 246.
 Mucin, 246.
 Mucosa, 261, 272, 288, 301.
 Mucosalivary glands, 247.
 Mucous glands, 246, 273.
 Mucous stratum, 33.
 Mugil, 178.
 Müller's Fluid, 71, 85.
 Muscularis mucosæ, 282, 289, 302.
 Musk glands, 35.
 Myriapoda, 80.
 Myripristis, 148.

N.

Nails, 34.
 Nautilus, 81.
 Nervous system of alimentary canal, 264,
 284, 292, 308.
 " " kidney, 135.
 " " liver, 97.
 " " salivary glands, 248.
 " " skin, 38.
 " " spleen, 237.
 " " thymus, 199.
 Nitrate of silver kidney, 135.
 Nyctotherus, 258.

O.

Octopus, 81.
 Oesophageal glands, 283.
 Oesophagus, 281.
 Ophidia, 148, 179.
 Opisthobranchiata, 81.
 Oral cavity, 262.
 Orbicularis oris, 37.
 Osmic acid, 4, 39, 208, 244.
 Ossein, 21.
 Oxyntic glands, 289, 290.

P.

Paeinian body, 35, 44, 198.
 Pancreas, 205-208, 217-220.
 " alveolar system, 206.
 " blood-vascular system, 217.
 " bibliography, 219.
 " canalicular system, 206.
 " centroacinar cells, 208.
 " development, 218.
 " etymology, 205.
 " gland substance, 206.
 " lymphatic system, 217.
 " minute structure, 205.
 " nervous system, 217.
 " preparation of, 208, 218.
 Panniculus adiposus, 35, 37.
 Panniculus carnosus, 37.
 Papilla foliata, 273.

Papillæ of tongue, 272
 Papillary layer of skin, 35, 37.
 Paramœcium, 258.
 Parietal cells of stomach, 290.
 Parietal salivary gland cells, 247.
 Peptic cells, 290.
 Perca, 178.
 Petromyzon, 178, 218.
 Peyer's patch, 302.
 Pflüger's method of dissociation, 248.
 Pharyngeal tonsil, 281.
 Pharyngobranchii, 33.
 Pharynx, 281.
 Phyllirhoë, 81
 Phyllopoda, 80.
 Pia mater, 65.
 Picric acid, 199, 208.
 Picrocarmine, 5.
 Pigment cells, 33.
 Pike, 178.
 Pisces, 33, 148.
 Placoid scales, 33.
 Placophora, 81.
 Platyhelminthes, 80.
 Pleura costalis, 149.
 Pleura pulmonalis, 149.
 Pleural membrane, 149.
 Pleuronectidae, 148.
 Plexus myentericus, 292, 302.
 Pneumatic duct, 148.
 Pneumodermon, 81.
 Polypterus, 148.
 Polyzoa, 80, 258.
 Porifera, 258.
 Portal vein, 94.
 Prickle cells, 36, 38, 264.
 Proteus, 147.
 Protista, 33.
 Protozoa, 79, 110, 257.
 Proventriculus, 291.
 Pseudopus, 148.
 Pseudo-stomata, 159.
 Pteropoda, 81, 110.
 Pulmonary vesicles, 157.
 Pyloric glands, 291.
 Python, 179.

R.

Radiolaria, 257.
 Rana temporaria, 283, 301.
 Ranvier's method for observing prickle cells, 39.
 Rattle of crotalus, 34.
 Recessus pharyngis medius, 281.
 Rectified spirit, 6.
 Renal chamber, 110.
 Renal tubules, isolation of, 135.
 Rennet glands, 290.
 Reptilia, 34, 148.
 Rete Malpighii, 35, 36.
 Rete mucosum, 35, 36.
 Retia mirabilia, 148.

Reticular cartilage, 2.
 Rossia, 81.
 Rotifera, 258.
 Rutherford's microtome, 4.

S.

Salivary glands, 243-250.
 " alveolar system, 245.
 " bibliography, 248.
 " blood-vascular, etc., systems, 247.
 " canalicular system, 244.
 " etymology, 243.
 " minute structure, 243.
 " nervous system, 248.
 " preparation of, 248.
 " tubes of Pflüger, 245.
 Scales, 33, 42.
 Scapirhynchus, 33.
 Schizopoda, 80.
 Seincus, 34.
 Scorpio, 80.
 Scutes, 34.
 Scyllium, 178.
 Sebaceous follicles, 35.
 Section mounting, 6.
 Segmental organs, 109.
 Selachii, cartilage of, 1.
 Sepia, 81.
 Serous glands, 273.
 Serous stratum, 33.
 Sharpey's fibres, 24.
 Shell gland, 109.
 Siluroidei, 148.
 Silver nitrate, action of on cartilage, 5.
 " as an injection, 135, 238.
 Siphonophora, 79.
 Skin, 33-44.
 Solitary glands, 396
 Spinal cord, 65-73.
 Spleen, 227-230, 235-240.
 " bibliography, 238.
 " blood-vascular system, 236.
 " corpuscular elements, 229.
 " etymology, 227.
 " lymphatic system, 237.
 " minute structure, 227.
 " nervous system, 237.
 " preparation of, 230, 238.
 " pulp tissue, 235.
 Staining in carmine, 40.
 " carmine and sulph-indigo-tate of soda, 40.
 " logwood, 85.
 " logwood and eosin, and picro-carmine, 6, 40.
 Stirling (W.), method of digestion, 39
 Stirling (A. B.), microtome, 4.
 Stomach, 287, 292.
 Stomatopoda, 80.
 Strata cornea et lucida, 35, 36.

Subcutaneous tissue, 35.
 Submaxillary gland, 243.
 Submucosa, 262, 282, 289, 302.
 Sudoriferous glands, 35.
 Sulph-indigotate of soda, 40.
 Sweat gland, 43.
 Sycon ciliatum, 258.

T.

Tactile corpuscles, 38, 44.
 Taste cells, 274.
 Taste goblets, 274.
 Taste organs, 273.
 Tegmental cells, 274.
 Teius, 179.
 Teleostei, 148, 218.
 Testicardines, 80.
 Thecosomata, 81.
 Thymus gland, 197-200.
 „ anatomy, 197.
 „ bibliography, 200.
 „ blood-vascular system,
 199.
 „ development, 199.
 „ etymology, 197.
 „ gland substance, 198.
 „ lymphatic system, 199.
 „ minute structure, 197.
 „ nervous system, 199.
 „ preparation of, 199.
 Thyroid body, 177-184.
 „ bibliography, 183.
 „ blood-vascular system,
 182.
 „ comparative anatomy,
 177.
 „ double staining of, 182.
 „ etymology, 177.

Thyroid body, hardening the, 182.
 „ lymphatic system, 182.
 „ minute structure, 180.

Tongue, 271.
 Torpedo, 178.
 Torquatella, 258.
 Tracheata, 109.
 Trigla, 178.
 Tubular glands, 283.
 Tubuli uriniferi, 120.
 Tunica dartos, 37.
 Tunicata, 81.
 Turbellaria, 258.

U.

Urachus, 110.
 Ureters, 110.
 Uric acid, 110.
 Urinary bladder, 110.
 Urinary canals of insecta, 109.
 Urodela, 148.
 Uropygial gland, 34.

V.

Valvulae conniventes, 299.
 Veella, hepatic canals of, 79.
 Vermes, 80, 109, 110.
 Vermiform appendix, 305.
 Villi, 300.
 Vorticella, 257.

W.

Water-vascular system, 109.
 Wattles, 34.
 Wirsung's canal, 206.
 Wolffian bodies, 110.

Y.

Yellow fibro-cartilage, 1.

INDEX.

SECTION B.

BOTANY AND PETROGRAPHY.

A.

Acacia melanoxylon, 103.
 Acer campestre, 279.
 Acer Pennsylvanicum, 278.
 Acerose leaf, 105.
 Acicular leaf, 105.
 Acuminate leaf, 105.
 Acute leaf, 105.
 Æcidium berberidis, 115.
 Æcidium compositarum, 113.
 Æcidium fruits, 116.
 Æcidomycetes, 210.
 Æcidospores, 116.
 Aërial roots, 143.
 Aërial stem of equisetum, 129.
 Air cavity of equisetum, 129.
 Air cavity of stoma, 107.
 Air spaces, intercellular, 106, 107.
 Albite, 270.
 Alburnum, 13.
 Algæ, 201, 210, 213.
 Allanite, 267, 268.
 Alternate leaves, 103.
 Alum solution as a mordant, 15.
 Amplexicaul leaf, 104.
 Anaptychia ciliaris, 202.
 Angiocarpous lichens, 202.
 Aniline green, 15.
 Anomalous forms of stem, 12, 32.
 Antheridia of fucus, 90.
 Antheridia of lycopods, 152.
 Antherozoids, 152.
 Apatite, 51, 194, 225.
 Apical cell, literature, 18.
 Apothecia, 202.
 Aqueous rocks, 53.
 Archegonia of lycopods, 152.
 Arkansas hone, 61.
 Aroideæ, 142.
 Arthur's seat, 294.
 Asci, 202.
 Ascidium, 106.
 Ascogonium, 214.
 Ascomycetes, 201, 210.
 Ash, winter buds of, 277.
 Aspidium (Lastrea) filix-mas., 144.
 Asplenium filix-fœmina, 144.

Augite, 49, 194, 224, 297.
 Australian Casuarinæ, 127.
 Axial vascular bundle, stem of pilularia,
 173.
 Azolla, 162, 163

B.

Banyan tree, 142.
 Barbadoes earth, 55.
 Barberry, 115.
 Bark, 12, 278.
 Barren fronds of equisetum, 129.
 Basalt, 191, 293.
 Basidia, 116.
 Bast cells, 13.
 Bast fibres, 9, 11, 13, 77.
 Bast parenchyma, 9, 77.
 Bast sheath, 77.
 Bast vessels, 77.
 Bastard toadflax, 143.
 Bathgate, 46.
 Baulhinia, 12.
 Beech, 9.
 Begonia, 106.
 Benzol, 61.
 Berberis vulgaris, 115.
 Betula alba, 279.
 Bibliography of Æcidium, 117.
 „ Bracken Fern, 75.
 „ Cork, 280.
 „ Dicotyledonous stem,
 16.
 „ Equisetum, 131.
 „ Fucus, 92.
 „ History of Microscopi-
 cal Petrography, 62.
 „ Laticiferous cells and
 vessels, 242.
 „ Leaf, 107.
 „ Lichen, 214.
 „ Lycopodium, 155.
 „ Monocotyledonous
 stem, 32.
 „ Pilularia globulifera,
 163.
 „ Root, 145.
 „ Serpentinogenic Rocks,
 etc., 62

Bignoniaceæ, 12.
 Bi-jugate leaf, 106.
 Binding substance, 193.
 Biotite, 51, 251.
 Bi-pinnate leaf, 106.
 Birch, 279.
 Bi-serrate leaf, 105.
 Blackburn quarry, Bathgate, 46.
 Blade, or lamina of leaf, 103, 105.
 Bleaching vegetable sections, 14.
 Bordered pits, 31, 286.
 Bracken fern, 75.
 Brassica alba, 105.
 Bristles, 11.
 Broom-rape, 143.
 Croussonetia, cystoliths, 260.
 Bundle sheath, 77, 131, 175.
 Bupleurum rotundifolium, 105.

C.

Calamites, 127, 129.
 Calcium carbonate, 260.
 Calcium oxalate, 107.
 Callosities, 276.
 Cambium, false, 32.
 Cambium zone, 10, 12, 141.
 Canada balsam cement, 60.
 Canada balsam, mounting in, 15.
 Capsella, 106.
 Carinal canal, 130, 131.
 Carmine solution, 15.
 Casuarineæ, 127.
 Caulerpa, 142.
 Cell forms, 13.
 Cellular pathology of cluster cup, 114.
 Central pith, 14.
 Cetraria Islandica, 201, 209.
 Chalk, to make sections of, 61.
 Chlorinated soda solution, 14.
 Chlorophyll, 89, 143.
 Chlorophyll bodies, 12, 107, 260.
 Chrysolite, 47.
 Chrysotile, 46.
 Cilate leaf, 105.
 Circinate vernation, 76.
 Classification of rocks, 53.
 Clays, to make sections of, 61.
 Clematis, 12.
 Clicker Tor serpentine, 49.
 Clinkstone, 191.
 Clove oil, 16.
 Cluster cup, 113.
 Coal, to make sections of, 61.
 Coccus cacti, 276.
 Collema, 211, 213, 214.
 Colt's foot cluster cup, 113.
 Compound leaves, 105.
 Compositæ, 141.
 Conceptacle, 87, 88.
 Coniferæ, 105, 286.
 Connate leaf, 105.
 Copper beech, 9.

Corallorrhiza innata, 142.
 Cordate leaf, 105.
 Coriaceous leaf, 106.
 Cork, formation of, 276.
 Corky cells of root, 144, 145.
 Cormophytes, 87.
 Corstorphine hill, 221.
 Cortex, 30.
 Cortical layer, 9, 131, 155, 174, 175, 232.
 Cotyledons, 11, 103.
 Coverack cove, 304.
 Covering leaves, 103.
 Crenate leaf, 105.
 Crustaceous lichens, 201.
 Crystals, intracellular, 107.
 Culm, 32.
 Cuneate leaf, 105.
 Cuscuta, 143.
 Cuticularisation, 11, 277.
 Cyperaceæ, 29.
 Cyperus alternifolius, 29.
 Cystococcus, 214.
 Cystolith, 260.

D.

Dahlia, 144.
 Dalmahoy hill, 190.
 Dammar solution, mounting in, 15.
 Dandelion, 105, 141.
 Decurrent leaf, 104, 105.
 Decussate leaf, 103.
 Dentate leaf, 105.
 Dermatogen, 10, 11.
 Diabase, 191, 221, 295.
 Diallagic-augite, 304.
 Diamond dust, 58.
 Dicotyledonous stem, 9.
 Digitate leaf, 105.
 Dimorphism, 211.
 Diorite, 191, 221, 251, 295.
 Discomycetes, 201.
 Dodder, parasitic roots of, 143.
 Dolerite, 190-196.
 Double staining, 15.
 Dracæna, 32, 279.
 Dunite, 46, 53.
 Duramen, 13.

E.

Ectocarp, 185.
 Elastic glue, 58, 59.
 Elliptical leaf, 105.
 Emarginate leaf, 105.
 Embryo, 10.
 Embryo sac, 10.
 Emery powder, 59.
 Endocarp, 186.
 Endocarpon pusillum, 214.
 Endodermis, 77, 144.
 Endogen, 31.
 Endosperm cells, 10.
 Ensiform leaf, 105.

Enstatite, 304.
 Ephebe synalissæ, 213.
 Epidermal system, 10, 11, 16, 30, 89,
 106, 130, 155, 174, 175, 232, 259,
 285.
 Epipogium Gmelini, 142.
 Equisetaceæ, 127.
 Equisetum arvense, 127, 128, 129.
 „ giganteum, 128.
 „ hyemale, 128.
 „ limosum, 128, 129.
 „ palustre, 128.
 „ pratense, 129.
 „ sylvaticum, 128, 129.
 „ Telmateia, 128, 129.
 Etymology of Apatite, 51.
 „ „ Augite, 49.
 „ „ Beech, 9.
 „ „ Biotite, 51.
 „ „ Bracken fern, 75.
 „ „ Cluster cup, 113.
 „ „ Cyperus, 29.
 „ „ Dandelion root, 141.
 „ „ Diabase, 221.
 „ „ Dolerite, 190.
 „ „ Equisetum arvense, 127.
 „ „ Euphorbia splendens,
 241.
 „ „ Felspar, 192.
 „ „ Ficus elastica, 259.
 „ „ Fucus, 87.
 „ „ Idioblast, 241.
 „ „ Juncus communis, 231.
 „ „ Leaf, 107.
 „ „ Lichen, 201.
 „ „ Lycopodium, 151.
 „ „ Magnetite, 51.
 „ „ Olivine, 47.
 „ „ Pikrite, 45.
 „ „ Pinus sylvestris, 285.
 „ „ Porphyritic basalt, 293.
 „ „ Rhododendron ponticum
 107.
 „ „ Ribes nigrum, 275.
 „ „ Serpentine, 303.
 „ „ Syenite, 251.
 „ „ Thallus and Conceptacle,
 87.
 „ „ Trichoblast, 241.
 Enonymus, 278.
 Euphorbia cyparissias, 210.
 Euphorbia splendens, 241.

F.

Fagus cuprea, 9, 279.
 Fagus sylvestris, 279.
 Fasciculated roots, 144.
 Felspar, 192, 297, 304.
 Fern, fronds of, 75.
 Fibro-vascular bundles, 12, 29, 31, 77,
 106, 131, 144, 176, 188, 234,
 286.

Fibrous roots, 144.
 Ficus elastica, 259, 260.
 Ficus Indica, 142.
 Ficus repens, 142.
 Filices, 162.
 Field horsetail, 127.
 Fleishy leaf, 106.
 Floral leaves, 103.
 Fluorite, 267.
 Foliage leaves, 103, 106.
 Fraxinus excelsior, 277.
 Fuchsin, 279.
 Fucaceæ, 87, 90, 142.
 Fucus cartilagenosus, 87.
 „ platycarpus, 88, 90.
 „ vesiculosus, 87.
 Fusiform roots, 144.
 Fusion of basalt, 296.

G.

Geological hammer, 57.
 Gimp peg, 58.
 Glands, 11, 17.
 Glandular cells, 12.
 Gleditschia, 104.
 Glæocapsa, 212.
 Glæolichenes, 211.
 Glycerine jelly, 77, 91.
 Glycerine mounting, 91.
 Gnetum, 12.
 Gonidia, 202.
 Gramineæ, 30, 31.
 Granite, 266, 295.
 Graphis elegans, 201, 209.
 Graphis scripta, 201, 209.
 Grasses, roots of, 144.
 Greenstone, 191.
 Grey granite, 251.
 Growing point, 11.
 Guard cells, 11, 107, 286.
 Gue graze serpentine, 304.
 Gymnocarpous lichens, 202.

H.

Hæmatite, 303.
 Hairs, 11.
 Hammer, geological, 57.
 Hard bast, 13.
 Hastate leaf, 105.
 Haughtonite, 251, 267, 268, 270.
 Haustoria, 143.
 Hedera helix, 142.
 Helleborus, 106.
 Heterœcism, 115.
 Heterophyllous leaf, 106.
 Holly, 106, 277.
 Hornblende, 270.
 Huttonian maxims, 191.
 Hymenial surface, 202.
 Hymenophyllaceæ, 143.
 Hyphæ, 115.
 Hypodermis, 106, 130, 154, 232, 259,
 285.

I.

Idioblast, 241, 259.
 Igneous rocks, 53.
Ilex aquifolium, 277.
 Imparipinnate leaf, 106.
 Incheolm, pikrite, 45.
 Insertion of leaf, 103.
 Intermediate tissue, 10.
 Internodes, 103.
 Interruptedly pinnate leaf, 106.
 Intrinsic characters of leaves, 104.
 Iodine from fucus, 87.
 Iris, 105.
 Iron, 297.
 Iserine, 297.
 Isoëtæ, 151, 152.
Isoëtæ setacea, 152.
 Ivy, 142.

J.

Jeweller's rouge, 59.
 Jugate leaves, 106.
Juncaceæ, 231.
Juncus communis, 231.
 „ „ eperdimis, 232.
 „ „ etymology, 231.
 „ „ fibro - vascular system, 234.
 „ „ hypodermis, 232, 233.
 „ „ intracortical system, 234.
 „ „ medulla, 234.
 „ „ minute structure of stem, 232.
Juncus conglomeratus, 232.
Juncus glaucus, 232.

K.

Kaolin, 295.
 King Charles's oak, 75, 76.
 Kynance Cove, 303.

L.

Labiataæ, 104.
Labradorite, 193, 297, 304.
 Lacinate leaf, 105.
 Lamina of leaf, 104.
Laminaria, 89.
 Lanceolate leaf, 105.
 Lapidary's bench, 58.
Lastræa filix-mas., 144.
 Latex, 13, 242.
Lathræa squamaria, 143.
 Laticiferous cells and vessels, 12, 13, 17, 241.
Lathyrus, 104.
 Leaf, arrangements of on stem, 103.
 „ bibliography, 107.
 „ blade, 105.

Leaf, etymology, 103.
 „ insertion of, 103.
 „ intrinsic characters, 104.
 „ kinds of, 103, 105.
 „ megascopic characters, 103.
 „ microscopic characters, 106.
 „ petiole, 104.
 „ sheath, 104.
 „ texture, 106.

Leathery leaf, 106.
Lemna arrhiza, 142.
Lemna, roots of, 142.
 Lenticels, 279.
Leontodon taraxacum, 141.
 Leptogium, 201.
 Levigation, 55.
 Liber, 10.
 Lichen, 201-204, 209-216.
 „ angiocarpous, 202.
 „ crustaceous, 201.
 „ foliaceous, 201.
 „ fruticose, 201.
 „ gymnocarpous, 202.
 „ heteromerous, 201.
 „ homiomericous, 201.

Ligule, 104.
Limonite, 193, 303.
 Linear leaf, 105.
 Lithocysts, 259.
Lizard serpentine, 45.
Ilherzolite, 45, 53, 295, 304.
 Lobed leaf, 105.
Lonicera caprifolium, 105.
Luzula vernalis, 232.
Lycopodiaceæ, 151, 152, 153, 162.
Lycopodium catharticum, 153.
 „ *chamæcyparissus*, 153.
 „ *clavatum*, 152, 153.
 „ *complantum*, 151.
 „ *fontinaloides*, 152.
 „ *Martensii*, 153.
 „ *myrsinitis*, 153.
 „ *phlegmaria*, 153.
 „ powder, 153.
 „ *rubrum*, 151.
 „ *selago*, 153.
 „ *Wildenovii*, 154.

M.

Maceration, 242.
Macrosporangia, 162, 185.
 Macrospores, 152, 188.
 Magnetite, 51, 194, 297.
Malotium Hildebrandii, 209.
Malpighiaceæ, 12.
 Mangrove, 142.
Marsilia, 161, 162, 163.
Marsiliaceæ, 161.
 Medullary cells, 9, 234.
 Medullary hyphal tissue, 203.
 Medullary rays, 9, 12, 14.
 Medullary sheath, 12, 13.

Megalospora, 203.
 Melaphyre, 191.
 Menyanthes trifoliata, 143.
 Mertensia, 144.
 Mesocarp, 185.
 Mica-diorite, 251.
 Microliths, 298.
 Microscopical petrology, historical record, 54.
 Microsporangia, 162, 185.
 Microspores, 152, 188.
 Mid-rib, 106.
 Minerals, section cutting of, 56.
 Mistleto, 143, 277.
 Mocotyledonous stem, 29-32.
 Mordant, 15.
 Mounting sections, 15, 61.
 Mucilaginous change, 90.
 Mucronate leaf, 105.
 Mycelium, 115.

N.

Napiform roots, 144.
 Nardoo, 162.
 Neottia nidus-avis, 143.
 Nepenthes, 106.
 Neres, 253.
 Noble serpentine, 303.
 Nodes, 103.
 Nostoc, 211, 214.
 Nucleus, 10.

O.

Obcordate, leaf, 105.
 Oblong leaf, 105.
 Ochrea, 104.
 Oedogonium, 91.
 Oil of cajeput, 15.
 Oil of cloves, 16.
 Oligoclase, 251, 268, 270.
 Olivier's method for staining suberised tissues, 279.
 Olivine, 47, 194, 297, 304.
 Omphalaria, 211, 213.
 Oogonium of fucus, 90.
 Oosphere of fucus, 91.
 Oospore of fucus, 91.
 Ophioglossum, 279.
 Opuntia vulgaris, 276.
 Orchideæ, 143.
 Orobanche, 143.
 Orthoclase, 267.
 Oval leaf, 105.
 Ovary, 10.
 Ovate leaf, 105.
 Overgrowth, 276.

P.

Palagonite rock, 295.
 Pallisade parenchyma, 106, 260.
 Palmatifid leaf, 105.
 Palmatipartite leaf, 105.

Palmatisect leaf, 105.
 Pandaneæ, 142.
 Pannaria triptophylla, 213.
 Papaver, 241.
 Parallel-veined leaves, 106.
 Paraphyses, 202.
 Parenchymatous cells, 13.
 Parpinnate leaf, 106.
 Parmelia parietina, 201, 209, 213.
 Parmelia tiliacea, 209.
 Pea, 106.
 Pectolite, 298.
 Pelicel cell, 91.
 Peltate leaf, 105.
 Perfoliate leaf, 105.
 Periblem, 10.
 Pericambium, 144.
 Pericarp of pilularia sporocarp, 185.
 Periderm, 278.
 Peridium, 117.
 Perithecia, 202.
 Peronia, 12.
 Pertusaria Wulfeni, 201, 203.
 Petiole, 103.
 Petiolule, 106.
 Phelloderm, 278.
 Phellogen, 278.
 Phloëm, 9, 12, 13, 30, 77, 131, 145.
 Phloëm Sheath, 154.
 Phycophæine, 89.
 Phycoxanthine, 89.
 Phyllode, 104.
 Phylloglossum, 151, 152.
 Phyllotaxis, 103.
 Physcia, 203.
 Picotite, 304.
 Pierolite, 45.
 Pieryte, Moravia, 46.
 Pikrite, Bathgate, 46.
 „ Fichtelgebirge, 46.
 „ Inchcolm, 45, 295, 304.
 Pileorhiza, 141.
 Pilularia globulifera, 161-164, 173 176, 185-189.
 „ axial bundle, 173.
 „ bundle sheath, 173.
 „ epidermis, 173.
 „ interlacunar cortex, 173.
 „ peripheral cortex, 173.
 „ perivascular cortex, 173.
 „ sporocarp, 185.
 „ stem, 173.
 Pinnate leaf, 105.
 Pinnatifid leaf, 105.
 Pinnatipartite leaf, 105.
 Pinnatisect leaf, 105.
 Pinnules of brake, 76.
 Pinus sylvestris, 278, 285, 286

Piper, 13.
 Pith, 9.
 Placenta of pilularia, 186.
 Platanus orientalis, 279.
 Plerome, 10.
 Plumule, 11, 30.
 Pollen grains, 277.
 Polycoccus, 214.
 Polygonum, 104.
 Pomaceæ, 278.
 Porphyritic basalt, 293.
 Portsoy serpentine, 313-318.
 Potatoe, 278
 Prehnite, 298.
 Premorse roots, 144.
 Prickles, 11.
 Primary cortex, 10, 11.
 Primary meristem, literature, 18.
 Procambium, 10, 12.
 Pronymcelium, 115.
 Prosenchymatoid parenchyma, 176.
 Prosenchymatous cells, 13.
 Protococcus, 213.
 Prout's elastic glue, 58, 59.
 Prunus cerasus, 279.
 Psilotum triquetrum, 142, 151.
 Puccinia graminis, 117.
 Pulverisation, 55.
 Pulvinus, 104.
 Putty powder, 59.
 Pycnidia, 203.
 Pyrenomycetes, 201.

Q.

Quadrinate leaves, 106.
 Quartz, 270, 251.
 Quercus suber, 279.
 Quinate leaves, 106.

R.

Rachis, 75, 106.
 Radicle, 11, 30.
 Ranunculus aquatilis, 106.
 Ranunculus circinatus, 143.
 Raphides, 11.
 Reniform leaf, 105.
 Repand leaf, 105.
 Resin, 13.
 Resin and bee's wax, 60.
 Resin passages, 286.
 Reticulately-veined leaves, 106.
 Rhizines, 201, 204.
 Rhizocarpeæ, 142, 161.
 Rhizoid, 88.
 Rhizome, 75, 130.
 Rhizophora mangle, 142.
 Rhododendron Ponticum, 103, 105.
 Rhomboidal leaf, 105.
 Ribes nigrum, 275, 278.
 Rocks, on the classification of, 53.
 ,, history of microscopical research,
 54.

Rocks, section cutting, and mounting,
 56.
 ,, serpentinogenic, 53.
 Root, 130, 141.
 Root cap, 141, 143.
 Root hairs, 130.
 Rostkovia, 232.
 Rotton stone, 59.
 Rough leaf, 105.
 Runcinate leaf, 105, 141.
 Rush candle, 232.
 Rushlight, 232.
 Rust, 117.

S.

Sagittate leaf, 105.
 Salix, 278.
 Salvinia, 142, 162.
 Salviniaceæ, 161.
 Sanguinaria, 241.
 Sapindaceæ, 12.
 Sargassum bacciferum, 88.
 Scabrous leaf, 105.
 Scalariform vessels, 77.
 Scales, 11.
 Scar or cicatrix, 103.
 Scattered leaves, 103.
 Schwendener's theory, 210-214.
 Schultze's solution, 276.
 Sclerenchymatous tissue, 76.
 Scorzonera hispanica, 241.
 Secondary meristem, 141.
 Secondary periderm, 278.
 Section bleaching, 14.
 Seed coat, 11.
 Seed leaves, 11, 103.
 Selaginella denticulata, 153.
 ,, exaltata, 152.
 ,, inæquifolia, 153.
 ,, Kraussiana, 153.
 ,, Martensii, 153.
 Selaginellæ, 143, 151-154.
 Semi-amplexicaul leaf, 104.
 Serpentine, Clicker Tor, 49.
 ,, Lizard, 45, 303.
 ,, Portsoy, 313-318.
 ,, Saxony, 49.
 Serpentinogenic rocks, 53.
 Serrate leaf, 105.
 Sessile leaf, 104.
 Shellac stick, 59.
 Sieve tubes, 10, 13, 31, 77, 176.
 Silver grain, 14.
 Simple leaf, 105.
 Sinuate leaf, 105.
 Slicing minerals and rocks, 57.
 Slit leaf, 105.
 Soda, chlorinated, for bleaching, 14.
 Soda in fucus, 87.
 Soft bast, 13.
 Soredia, 203.
 Spathulate leaf, 105.

Spermatia, 116, 203.
 Spermogonium, 113, 115, 203.
 Spine, 251, 267.
 Spines, 106.
 Spiny leaf, 105.
 Spongy parenchyma, 106.
 Sporangia, 117.
 Spores, 116.
 Sporocarps, 161-163, 185.
 Staining vegetable sections, 15, 16.
 Starch, dumb-bell shaped grains, 242.
 Stem, anomalous forms of, 12, 32.
 „ dicotyledonous, 9.
 „ monocotyledonous, 29.
 Sterigmata, 116, 203.
 Sticta pulmonacea, 201, 204, 209.
 Stinging hairs, 11.
 Stipules, 104.
 Stoma, 11, 107, 130.
 Suberisation, 276.
 Suberous cortical tissue, 278.
 Suberous tissue, 11.
 Sub-hymenial layer, 203.
 Submerged leaves of Rhizocarpeæ, 161.
 Subrotund leaf, 105.
 Succulent leaf, 106.
 Syene, 251.
 Syenite, red, of Lairg, 251-256.
 Syenite, white, of Lairg, 265-270.
 Syenitic granite, 251.
 Syenitic greenstone, 251.
 Symmetrical leaf, 106.
 Symplast, 242.
 Synalissa, 211-213.

T.

Tachylite, 297.
 Tap roots, 144.
 Taraxacum dens-leonis, 141.
 Taraxacum officinale, 141.
 Teleutospores, 117.
 Temporary cambium, 30.
 Tendrils, 106.
 Ternate leaf, 106.
 Terpininate leaf, 106.
 Thallopiphytes, 87.
 Thallus, 87, 88, 201, 202.
 Thesium linophyllum, 143.
 Thlaspi perfoliatum, 104.
 Titaniferous iron, 50, 194, 225, 297.
 Tmesipteris, 151.
 Toadflax, 143.
 Toothwort, 143.
 Trapa natans, 142.
 Trentepohlia, 213.
 Triangular leaf, 105.

Trichites, 297.
 Trichoblast, 241.
 Trichogyne, 214.
 Trijugate leaf, 106.
 Triternate leaf, 106.
 Truncate leaf, 105.
 Tuberos roots, 144.
 Turkey stone, 61.
 Turpentine, 16.
 Tussilago farfara, 113.

U.

Umbrella plant, 29.
 Unsymmetrical leaf, 106.
 Uredineæ, 115.
 Uredo fruits, 117.
 Uredospores, 117.
 Usnea barbata, 201, 203, 209.
 Utricular cells and vessels, 12, 17.

V.

Vallecular lacunæ of equisetum, 131.
 Vascular bundle sheath, 77, 131, 175.
 Vaucheria, 91.
 Venation of leaves, 106.
 Vegetable tissues, preparation of, 14, 18.
 Veneration, circinate, 76.
 Vessels, 13.
 Vetch, 106.
 Vicia sepium, 104.
 Viridite, 224.
 Viscum album, 143, 277.

W.

Waller's wax, 59.
 Water-of-Ayr stone, 61.
 Wavy leaf, 105.
 Whinstone, 191.
 Winged stem, 105.
 Wood, 9, 12.
 Wood parenchyma, 77.

X.

Xylem, 9-13, 29, 77, 131, 145.

Y.

Yttrocerite, 267.

Z.

Zeolites 192, 225, 298.
 Zoospores, 213.

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